EFFECTS OF PARTICIPANT'S ROLE AND NARRATIVE TOPIC ON VISUAL ATTENTION IN ADULTS WITH AUTISM DURING A STRUCTURED INTERACTION

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Individuals with autism spectrum disorders (ASD) have well-documented difficulties on face perception tasks. Although visual attention has been examined to clarify the nature face processing in ASD, there is no consensus among research concerning how visual attention differs in individuals with ASD, and less is known about how individuals with ASD attend to faces during interactions. The current study used a novel method to simulate a video-mediated interaction and thereby examine the effects of group (autism, control), participant's role (listening, responding), and topic demands (cognitive and social) on visual attention during an interactive context. Nineteen male adults with ASD and 19 male typically developing (TD) adults, matched on age and measures of IQ, completed a task that involved alternating between responding to narrative topics and listening to their partner (a confederate) respond to the same topics. Unbeknownst to participants, prerecorded videos were shown instead of a live-video feed and eye movements were recorded. Additional analyses examined the effects of stimulus type, individual differences, and temporal-specific differences in group viewing proportions. Overall, patterns of visual attention were similar for participants with and without ASD, indicating that top-down factors moderate gaze in ASD. When between-group differences were identified, the majority of differences revealed reduced attention to facial regions or attenuated shifts in gaze in the autism group, but not atypicalities in the overall patterns of gaze. However, results indicated that both the distribution of attention to facial features and the extent of between-group differences in gaze differed depending on whether static or dynamic faces were viewed. In addition, reduced gaze to the face during the listening condition and reduced overall gaze to the nose distinguished the autism group from the control group. Participant characteristics (i.e., social anxiety, social skills participation) and contextual factors (i.e., emotional, dense, or disfluent speech) associated with within-group and between-group variability were also identified. Findings highlight the importance of examining visual attention using ecologically-valid designs in order to conceptualize face processing in ASD. Possible explanations for group differences in gaze to the nose, rather than the eyes or the mouth, are discussed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Autism spectrum disorders (ASDs) are a relatively common group of disorders which are characterized by pervasive impairments in social, communicative, and behavioral functioning (Kogan et al., 2009). However, additional impairments related to face perception are also widely documented in the autism literature. By examining behavioral outcomes on face perception tasks, research has shown that individuals with ASD perform worse than typically developing (TD) individuals on tasks requiring the identification, classification, and recognition of faces and facial attributes (e.g., Dawson, Webb, & McPartland, 2005; Jemel, Mottron, & Dawson, 2006; Sasson, 2006; Weigelt, Koldewyn, & Kanwisher, 2012). More important, difficulties on these tasks are thought to indicate that underlying impairments in face processing exist in terms of how individuals with ASD encode, store, and retrieve visual information conveyed by faces.

In addition, studies have shown that impairments related to face perception are present early in development (Chawarska & Shic, 2009; Chawarska, Volkmar, & Klin, 2010; Jones, Carr, & Klin, 2008; Shic, Macari, & Chawarska, 2014) and persist into adulthood for individuals with ASD, despite developmental improvements (e.g., Rump, Giovannelli, Minshew, & Strauss, 2009). Moreover, extensive research indicates that behavioral, neurological, and electrophysiological correlates of face processing continue to differentiate adults with ASD from TD adults during both face recognition (for reviews, see Dawson et al., 2005; Jemel et al., 2006) and emotion recognition (for review, see Harms, Martin, & Wallace, 2010). Thus, these findings suggest that face processing impairments are pervasive in ASD.

Although impaired face processing abilities are not considered to be an essential diagnostic characteristic of ASD (American Psychiatric Association, 2013; American Psychiatric Association, 2000), these deficits are important clinically as accurate face perception is fundamental for the typical development of many socio-communicative skills that are specifically associated with ASD. For example, among TD individuals, accurate recognition of facial expressions is a basic requirement for emotional reciprocity (Morrison & Bellack, 1981) and is associated with later social competence (for reviews, see Izard et al., 2001; Mostow, Izard, Fine, & Trentacosta, 2002). Similarly, facial information such as eye gaze facilitates language learning by clarifying verbal communication and providing information about others' intentions (Hanna & Brennan, 2007; Itier, Villate, & Ryan, 2007). Thus, given the potential functional role impairments in face perception may play in the atypical development of other socio-communicative skills in ASD, understanding the etiology of these impairments and the face processing deficits that underlie them is important for accurately characterizing the development of this disorder.

Attempts by researchers to explain *why* individuals with ASD have impaired face processing abilities have focused on characterizing differences in the information processing strategies employed by individuals with ASD during face perception tasks, relative to those employed by TD individuals (Curby, Willenbockel, Tanaka, & Schultz, 2010). Specifically, these studies have examined the role of featural processing (i.e., processing information related to isolated facial features) and configural processing (i.e., processing information related to the spatial configuration among facial features) during face discrimination and face recognition tasks using methodologies developed to characterize face processing in TD adults. An essential feature of these paradigms is that face stimuli are altered in way that changes the amount of configural information (e.g., by showing only isolated facial features) or featural information (e.g., by blurring faces using high-spatial frequency filters) that is available during experimental conditions. By comparing performance when viewing unaltered face stimuli (i.e., intact, upright faces) to that when viewing altered face stimuli (e.g., inverted faces), it is possible to evaluate the importance of configural or featural processing based on the relative decrease in performance across experimental conditions. As a result, these studies are able to provide further and more specific evidence of atypical face processing in individuals with ASD.

With regard to face perception in TD individuals, research has shown that in general, adults have more difficulty recognizing faces and making facial discriminations when configural information is altered (e.g., by inverting faces; Searcy & Bartlett, 1996) or unavailable (e.g., by showing only isolated parts of faces; Piepers & Robbins, 2012). These findings have been interpreted as indicating that when both featural and configural information is available, configural information is more important for face processing in TD individuals (e.g., Ingvalson & Wenger, 2005). Moreover, this reliance on configural processing makes face perception unique compared to other types of visual perception, which rely more heavily on featural processing (for review, see McKone & Robbins, 2011).

In contrast to the TD literature, the majority of studies examining face perception in ASD have found either that individuals with ASD do not perform differently depending on the type of facial information available or that their performance advantage for configural information is significantly less than that exhibited by TD individuals (for review, see Weigelt et al., 2012). Thus, researchers have suggested that a difference in information processing strategies, namely, a bias for processing featural information from faces, prevents individuals with ASD from abstracting the relevant information needed to process faces efficiently and accurately (e.g., Jemel et al., 2006; Riby, Doherty-Sneddon, & Bruce, 2008). However, because these studies still use behavioral outcomes to indirectly assess face processing, their findings are limited as they permit only inferences to be made concerning how information processing strategies contribute to less accurate face perception in ASD.

In order to better understand how impairments in face perception arise in ASD, research has begun to use eye tracking to examine eye movements during face processing (Boraston & Blakemore, 2007). Because eye tracking provides an on-line index of gaze, studies using this technology are able to directly elucidate differences in how individuals with and without ASD process faces in real-time (Liversedge & Findlay, 2000). Specifically, face processing research has examined fixations, periods of time between saccades when gaze is relatively stable. Compared to saccades, visual acuity and color sensitively are optimized during fixations, which allows pattern information to be abstracted (Henderson, 2003). Moreover, because fixations are closely tied to visual attention, they serve as an index of early information processing (i.e., the encoding of facial information; for review, see Rayner, 1998). As a result, it has been suggested that differences in visual attention, such as the degree to which one fixates facial features (e.g., eyes, nose, and mouth), may influence one's ability to identify, interpret, and remember facial information. This intuitive relationship between visual attention and face perception is also supported by research with TD individuals, which has shown that eye movements exhibited when scanning faces are related to performance on face perception tasks (Henderson, Williams, & Falk, 2005). Thus, atypical visual attention may be associated with impaired face processing abilities in individuals with ASD.

However, before reviewing the extant research using eye tracking to assess face processing in individuals with ASD, an important caveat must be noted. Although research has independently examined the relationship between face perception and both information processing strategies (i.e., configural and featural) and visual attention, little research has attempted to characterize how information processing strategies and patterns of visual attention may be related (Bombari, Mast, & Lobmaier, 2009; Schwarzer, Huber, & Dümmler, 2005; Williams & Henderson, 2007). Specifically, one study found that configural processing was characterized by a greater number of across-feature fixations (e.g., fixating the eyes, then the nose) compared to featural processing, which was characterized by a greater number of within-feature fixations (e.g., consecutive fixations within the eye region; Bombari et al., 2009). Similarly, another study examining gaze during a face categorization task found that individuals who classified faces based on a single feature, suggesting a featural strategy was used, exhibited less distributed attention to faces compared to individuals who classified faces based on multiple facial features, suggesting a configural strategy was used (Schwarzer et al., 2005). However, no differences in gaze patterns were found between featural and configural processing conditions during a third study using an inversion task (Williams & Henderson, 2007). Given these limited and conflicting results, visual attention has been exclusively examined in autism research as a general indicator of information processing during face perception tasks, without attempting to classify gaze patterns as reflecting configural or featural processing strategies.

1.1 EYE-TRACKING RESEARCH WITH INDIVIDUALS WITH ASD

Consistent with eye-tracking research on face processing abilities in nonclinical populations, eye-tracking research with individuals with ASD has typically examined the distribution and duration of fixations to facial regions. In particular, research has focused on how individuals with ASD attend to the eye region of faces relative to the mouth region, with mixed findings reported. Although some studies have reported decreased attention to the eyes, increased attention to mouths, or a combination of these effects (e.g., Corden, Chilvers, & Skuse, 2008; Hernandez et al., 2009; Klin, Jones, Schultz, Volkmar, & Cohen, 2002), other studies have failed to find differences in visual attention between individuals with ASD and TD individuals (e.g., Bal et al., 2010; Falck-Ytter, Fernell, Gillberg, & von Hofsten, 2010; McPartland, Webb, Keehn, & Dawson, 2011). Moreover, additional research has reported divergent findings depending on experimental conditions, which further complicates any global conclusions regarding visual attention to faces in individuals with ASD (e.g., Kirchner, Hatri, Heekeren, & Dziobek, 2011; Neumann, Spezio, Piven, & Adolphs, 2006; Spezio, Adolphs, Hurley, & Piven, 2007). Although researchers have typically attributed these discrepancies to differences in the type of face stimuli used (i.e., static, dynamic, and dynamic-interactive), only one study has examined visual attention to both static and dynamic faces in individuals with ASD (Speer, Cook, McMahon, & Clark, 2007). Given the paucity of research, eye-tracking findings are reviewed separately for each type of stimulus so that the effects of stimulus properties on visual attention can at least be tentatively considered.

1.1.1 Static face stimuli

The majority of studies on visual attention to faces in individuals with ASD have used static faces with either neutral or emotional expressions, and there is some evidence that the type of facial expression may influence whether or not between-group differences in visual attention are found. Among the existing research using static faces with neutral expressions, only a few studies have reported atypical visual attention in young children (Chawarska & Shic, 2009), adolescents (Dalton et al., 2005) or adults with ASD (Gastgeb, Wilkinson, Minshew, & Strauss, 2011; Hernandez et al., 2009). Moreover, differences among adult samples were subtle, as adults with ASD differed in their amount of visual attention to the eyes relative to TD adults, but not in their general distribution of visual attention to facial regions (Gastgeb et al., 2011; Hernandez et al., 2009). In addition, numerous studies with both children (Anderson, Colombo, & Jill Shaddy, 2006; Bar-Haim, Shulman, Lamy, & Reuveni, 2006; McPartland et al., 2011; van der Geest, Kemner, Verbaten, & van Engeland, 2002) and adults with ASD (Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009; Kirchner et al., 2011; Sterling et al., 2008) have found little to no differences in visual attention to static, neutral faces compared to TD individuals.

Together, these studies provide only weak evidence of atypical visual attention to faces in individuals with ASD. Still, it must be noted that even subtle differences in visual attention may have a negative effect on face perception, and thus, these differences may be meaningful in conceptualizing the nature of face processing deficits in ASD. For example, equivalent amounts of time spent looking at the eyes despite fewer fixations may indicate less efficient, slower processing. As a result, even subtle differences may be indicative of less automatic or less proficient face processing in individuals with ASD.

In comparison, research using static faces with emotional expressions has yielded more heterogeneous findings. Although several studies have reported that children and adults with ASD exhibit typical patterns of visual attention when viewing faces with emotional expressions (Kirchner et al., 2011; Neumann et al., 2006; Spezio et al., 2007; van der Geest et al., 2002), other studies have reported that adults with ASD exhibit decreased attention to the eyes of emotional faces compared to TD adults (Corden et al., 2008; Dalton et al., 2005; Hernandez et al., 2009; Kliemann, Dziobek, Hatri, Steimke, & Heekeren, 2010; Pelphrey et al., 2002;

Rutherford & Towns, 2008). However, some of these reported differences in visual attention may be erroneous as methodological problems exist within the available research, including between-group differences in IQ (Hernandez et al., 2009; Pelphrey et al., 2002) and small sample sizes (*n*=5; Pelphrey et al., 2002).

Moreover, qualitative differences across studies may help clarify these divergent findings, as differences in visual attention have more commonly been reported by studies that have used difficult experimental tasks. Specifically, individuals with ASD may be more likely to exhibit atypical visual attention when faces are viewed briefly (Kliemann et al., 2010), are partially displayed (Neumann et al., 2006; Spezio et al., 2007), or express complex emotions (e.g., scheming, thoughtful, flirting; Rutherford & Towns, 2008). These studies suggest that task difficulty may moderate differences in visual attention between individuals with ASD and TD individuals, though more systematic research is need to directly test this possibility. In particular, research using dynamic face stimuli will be important. Because dynamic faces have unique, temporal-processing demands and often require intermodal processing of audiovisual information, studies using static face stimuli may underestimate the degree to which visual attention is atypical in individuals with ASD (Bar-Haim et al., 2006; Buchan, Paré, & Munhall, 2007; Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012).

1.1.2 Dynamic face stimuli

Despite increased recognition of the need to assess visual attention using more ecologically-valid, face stimuli, only a few studies have examined visual attention using dynamic faces. However, among the studies that have, the majority have found that individuals with ASD exhibit decreased attention to the eye region of faces compared to TD individuals (Jones et al., 2008; Klin et al., 2002; Nakano et al., 2010; Norbury et al., 2009; Speer et al., 2007). Interestingly, all of the studies that found differences in visual attention between-groups used complex videos including audiovisual information and complex backgrounds, whereas the two studies that did not find between-group differences used silent videos of dynamic faces with simple backgrounds (Bal et al., 2010; Falck-Ytter et al., 2010). Thus, it may be that differences in visual attention are more pronounced when individuals with ASD view complex, dynamic, audiovisual videos of faces.

A study by Speer and colleagues (2007) provides more direct support for this possibility, as children with ASD exhibited atypical visual attention when viewing dynamic videos with two or more people, but not when viewing either static images with multiple people or dynamic videos with only one person. Though preliminary, these results suggest that there may be qualitative differences in how individuals with ASD attend to faces depending on the complexity of stimuli. Thus, it is critical that research goes beyond identifying whether or not group differences in visual attention exist and explores moderating factors that may contribute to group differences, as well as to variability in visual processing among individuals with ASD.

1.1.3 Dynamic-interactive face stimuli

Although studies using dynamic faces improve on prior research, they still fail to capture the complex, interactive nature of face processing during social contexts (Risko et al., 2012). Considering there is evidence that the addition of auditory information alone may influence the typicality of gaze patterns in individuals with ASD during passive viewing conditions (Speer et al., 2007), it seems unlikely that the interactive component of social interactions (i.e., having to listen and respond to another person) will have only a trivial effect on visual attention to dynamic faces. Consistent with this, research has shown that social presence, even when interactions do not take place, influences how TD individuals attend to faces (Foulsham, Walker, & Kingstone, 2011; Laidlaw, Foulsham, Kuhn, & Kingstone, 2011). Thus, understanding how individuals with ASD process faces during in-vivo contexts is critical as research attempts to conceptualize how impairments in face perception arise.

To date, six studies have examined visual attention in individuals with ASD during live, interactions (Doherty-Sneddon, Riby, & Whittle, 2012; Doherty-Sneddon, Whittle, & Riby, 2013; García-Pérez, Lee, & Hobson, 2007; Nadig, Lee, Singh, Bosshart, & Ozonoff, 2010; Riby, Doherty-Sneddon, & Whittle, 2012; Tantam, Holmes, & Cordess, 1993). However, only one of these studies used eye tracking to assess gaze (Nadig et al., 2010), and all of these studies assessed overall visual attention to faces (i.e., face-directed gaze) rather than visual attention for specific facial regions. Findings from these studies are further limited in that gaze was examined during semi-structured interviews which were generally conducted by an experimenter, though a study by Doherty-Sneddon and colleagues (2013) also included a condition in which a familiar adult conducted the interview. Finally, interviewers in the majority of these studies where not blind to diagnosis, and in the two studies that examined interviewers' behaviors, differences were found related to how interviewers interacted with participants with ASD compared to TD participants (García-Pérez et al., 2007; Tantam et al., 1993). As a result, it is unclear to what extent findings from these studies generalize to day-to-day interactions in which the experiences of conversational partners are relatively similar. In particular, gaze patterns may differ when there is less of a status differential between members of a dyad (e.g., during interactions between peers), as well as when there is greater reciprocity during an interaction (e.g., the demands associated with speaking and listening are shared by members of a dyad). Furthermore, because the behaviors of interviewers' were variable, it is not clear to what extent the observed differences in face-directed gaze are endogenous, reflecting an individual's diagnosis of ASD, or exogenous, reflecting dyadic interactions when one member has ASD.

With these constraints in mind, only a few differences in face-directed gaze have been reported (Doherty-Sneddon et al., 2012; Riby et al., 2012; Tantam et al., 1993). Specifically in one study, adolescents with ASD demonstrated less face-directed gaze across all phases of an interaction (i.e., listening, thinking, speaking) compared to developmentally-matched control children (Riby et al., 2012). However, a similar study reported that participants in the autism group exhibted reduced face-directed gaze, but only during listening portions of an interaction (Doherty-Sneddon et al., 2012). Moreover, it is notable that in both of these studies, shifts in face-directed gaze across interaction phases did not differ between the two groups. Finally, in the only study that included adults, a nonsignificant trend was found suggesting that adults with Asperger's disorder exhibited less face-directed gaze compared to TD adults (Tantam et al., 1993). Unlike the studies noted above, results from the study by Tantam and colleagues (1993) indicated that adults with Asperger's disorder exhibited an atypical pattern of gaze during the interaction, such that they looked more at the interviewer's face when they were speaking compared to listening.

However, in the remaining three studies, including the only eye-tracking study, no differences in face-directed gaze were found between adolescents with ASD and TD adolescents, regardless of their conversational role (Doherty-Sneddon et al., 2013; García-Pérez et al., 2007; Nadig et al., 2010). Despite these null findings, it is important to note that between-group differences may exist in the processes that underlie these similarities in visual attention. For example, Nadig and colleagues (2010) hypothesized that children with ASD may have exhibited typical, face-directed gaze when speaking about their interests during the interaction because of the highly repetitive nature of their interests, thus reflecting scripting rather than increased social engagement. Support for this possibility is provided by another study in which researchers, who were blind to participants' diagnostic statuses, rated adolescents with ASD as less engaged during interviews compared to TD adolescents, even though no between-group differences in face-directed gaze were found (García-Pérez et al., 2007).

Thus, more systematic research is needed to explore how the context, composition, and content of interactions may moderate gaze patterns in both individuals with and without ASD. In addition, future research examining potential, between-group differences in the distribution of gaze to facial regions and in the real-time fluctuations of eye movements is important as results from these studies may help explain qualitative differences during interactions with individuals with ASD.

1.1.4 Summary and limitations of current research

Overall, there is substantial variability among the findings reported by research on visual attention to faces in individuals with ASD; however, this is not surprising considering the variability that exists across studies in terms of face stimuli and task demands. In addition, research suggests that substantial differences in visual attention exist among individuals with ASD (Nakano et al., 2010; Rice, Moriuchi, Jones, & Klin, 2012), and thus, individual differences may contribute to discrepancies within the autism literature. In particular, there is evidence that differences in gaze among individuals with ASD may be related to measures of behavioral functioning, including verbal ability (Norbury et al., 2009), language comprehension (Norbury et al., 2009), nonverbal communication (Falck-Ytter et al., 2010), social impairments (Falck-Ytter, 2008; Jones et al., 2008; Kirchner et al., 2011; Klin et al., 2002), and autism symptoms (Nadig et al., 2010).

Despite these caveats, atypical visual attention in individuals with ASD has been most consistently reported by studies using dynamic stimuli, whereas results from studies using static stimuli have been more equivocal. Still, findings from both of these types of research suggest that the complexity or difficulty of experimental tasks may influence whether atypical visual attention is found in individuals with ASD. Although atypical patterns of visual attention for dynamic stimuli have been inconsistently replicated by the few studies using dynamic-interactive faces, the imprecise way that gaze was assessed by these studies may have obscured subtle, between-group differences in visual attention. As a result, these heterogeneous findings preclude drawing any specific conclusions regarding the typicality of visual attention to faces in individuals with ASD; nevertheless, they globally suggest that gaze patterns during face processing are not static and that atypical visual attention is not ubiquitous among individuals with ASD.

In order to clarify the significance of these divergent findings, several limitations within the current literature must be addressed. First, research using more carefully composed samples is needed as much of the existing research has included participants who vary significantly in age. This variability in sample demographics is especially problematic given that many studies have reported findings using small samples (ns<15; Bar-Haim et al., 2006; Doherty-Sneddon et al., 2013; Pelphrey et al., 2002; Speer et al., 2007; Spezio et al., 2007). Moreover, despite research indicating that gaze patterns in clinical and nonclinical populations are variable during face processing, relatively few autism studies have attempted to unpack individual differences in visual attention (Peterson & Eckstein, 2013a; Rice et al., 2012). Given the significant diversity within the autism phenotype, ongoing research examining how individual differences moderate visual attention in ASD is needed, especially since these associations may be task-dependent. Likewise, the extensive variability in study methodologies further hinders comparisons across studies, and at present, the significance of these differences is unclear, as only a few studies have examined how stimulus properties or task demands influence patterns of visual attention to faces. Instead, the majority of eye-tracking studies have used static face stimuli and highly-controlled face perception tasks with explicit goals (e.g., identify facial expressions), thereby eliminating any potential analysis of moderating factors (e.g., Kirchner et al., 2011).

Thus more broadly, autism research is limited as it has treated visual attention during face processing as a static construct. This approach differs greatly from that taken by TD research which conceptualizes visual attention during face processing as a dynamic and complex process (for a review, see Karatekin, 2007). Thus, although several factors have been suggested post-hoc as explanations for why atypical visual attention was or was not found in autism research, it is critical that research begins to systematically explore how endogenous and exogenous factors moderate visual attention in individuals with ASD, particularly in interactive contexts. Because a dynamic account of visual attention has already been established in typical development, findings from research with TD individuals may help elucidate parameters that constrain visual attention to faces in ASD.

2.0 MODERATORS OF VISUAL ATTENTION IN TYPICAL DEVELOPLMENT

In contrast to autism research, extensive research with TD individuals has shown that visual attention during face processing is variable, as it is moderated by both bottom-up, stimulus-driven processing (e.g., perceptual saliency of visual information, stimulus features) and top-down, context-driven processing (e.g., observer's goals, prior experience, task demands; Henderson, 2003). However more fundamentally, modulation of visual attention in typical development can be conceptualized within an information processing framework, as the interaction between a perceptual system's capacity and its processing load contribute to the way attention is distributed during tasks (Ingvalson & Wenger, 2005).

Specifically, information processing theory posits that perceptual systems can be classified as having limited, unlimited, or super capacities based on how a system is affected by increases in processing load (Wenger & Townsend, 2000). As demands are increased, systems with limited capacities exhibit less efficient processing; those with unlimited capacities, exhibit stable processing efficiency; and those with super capacities, exhibit more efficient processing. Thus for systems with limited capacities, selective attention is required when processing loads are high, as these systems are not capable of simultaneously processing all features within a stimulus or all stimuli within a task (Goffaux, Jemel, Jacques, Rossion, & Schyns, 2003). In these contexts, bottom-up and top-down processing provide feedback to perceptual systems, thereby guiding processing and moderating how attention is employed during tasks (Kastner, &

Ungerleider, 2001. However, the capacity for a given system is contingent on the level of analysis (e.g., processing isolated input vs. processing during an entire task; Bindemann, Burton, & Jenkins, 2005; Wenger & Townsend, 2000). For example, face perception research on feature identification has shown that TD individuals demonstrate unlimited-capacity to super-capacity during some tasks (e.g., Ingvalson & Wenger, 2005) and limited capacity in others (e.g., Wenger & Townsend, 2000).

Although a more thorough discussion of information processing theory is beyond the scope of this paper (for a complete discussion, see Wenger & Townsend, 2001), research with TD individuals has consistently shown that top-down factors moderate how attention is distributed during face perception tasks that involve processing either static faces (e.g., Peterson & Eckstein, 2012; Schyns, Bonnar, & Gosselin, 2002) or dynamic faces (e.g., Doherty-Sneddon, Bonner, & Bruce, 2001; Edelmann & Hampson, 1981). However, unlike top-down factors, the effects of bottom-up factors on the distribution of gaze during naturalistic contexts involving dynamic, visual stimuli appear to be minimal (i.e., Rothkopf, Ballard, & Hayhoe, 2007). Together, these findings suggest that face processing of entire face stimuli is associated with a limited capacity and that top-down factors primarily influence how visual attention is allocated to dynamic faces. As a result, the remainder of this section focuses specifically on research that has examined top-down moderators of visual attention to dynamic faces. Although a variety of top-down factors have been shown to influence how TD individuals attend to faces (for review, see Henderson, 2003), the discussion of top-down moderators is further limited to studies examining the effects of conversational role, social anxiety, and task demands, as these factors are examined in the current study.

However with regard bottom-up factors, it is important to note that because the level of analysis affects how a system's capacity is characterized, differences in bottom-up processing may still contribute to divergent findings within the autism literature on visual attention to faces. In particular, bottom-up factors may more reliably influence gaze during face perception tasks in which across-task differences in stimulus properties are more pronounced (e.g., when comparing processing for dynamic stimuli to that for static stimuli). Consistent with this possibility, TD research has shown that face perception is affected by whether static or dynamic stimuli are viewed (e.g., Lander & Davies, 2007). Thus, although bottom-up factors do not likely contribute to how individuals with ASD attend to dynamic faces, research exploring potential, bottom-up moderators of visual attention in ASD is still needed to clarify and integrate findings across studies using different types of stimuli.

2.1 CONVERSATIONAL ROLE

During dyadic interactions, TD individuals generally exhibit more eye contact[1] when they are listening compared to speaking (e.g., Exline, Gray, & Schuette, 1965; Turkstra, Ciccia, & Seaton, 2003). For example, one study reported that adolescents looked at their partner 65% of the time when they were listening and only 40% of the time when they were speaking (Turkstra et al, 2003). Although this shift in eye contact is commonly cited, researchers have proposed both cognitive and social explanations for why it occurs. Specifically, cognitive accounts argue that eye contact decreases when speaking because speech production is more cognitively

[1] Terms such as eye gaze and eye contact are commonly used in research examining differences in gaze depending on conversational role. However, because face perception was not a focus of these studies and gaze was manually coded, operational definitions of these terms do not denote where within a face gaze was specifically directed.

demanding than speech recognition, and thus, this shift in gaze is attributed to top-down differences in task difficulty (e.g., Griffin, 2004). In contrast, social accounts argue that eye contact increases when listening to communicate to others that one is attentive, and thus, this shift in gaze is attributed to differences in an individual's goals (e.g., Cary, 1978). However, these explanations are not mutually-exclusive, and thus, both cognitively-mediated and socially-mediated top-down factors may contribute to changes in visual attention when listening compared to speaking.

Despite extensive research on face processing, relatively few studies have examined visual attention and conversational role in individuals with ASD. However recently, a growing number of autism studies have examined face-directed gaze during interactions (Doherty-Sneddon et al., 2013; Doherty-Sneddon et al., 2012; García-Pérez et al., 2007; Nadig et al., 2010; Riby et al., 2012; Tantam et al., 1993). Although these studies have generally examined gaze during the context of interviews, they provide preliminary evidence that individuals with ASD exhibit a typical shift in face-directed gaze when speaking compared to listening (Doherty-Sneddon et al., 2012; Doherty-Sneddon et al., 2013; García-Pérez et al., 2007; Nadig et al., 2010; Riby et al., 2012, but cf., Tantam et al., 1993). However in some cases, the amount of face-directed gaze exhibited by individuals with ASD was either reduced overall (Doherty-Sneddon et al., 2012) or less during listening portions of the interaction compared to that exhibited by TD individuals (Riby et al., 2012). Still, it is unclear based on these studies how visual attention to specific facial regions is influenced by conversational role in individuals with ASD.

2.2 SOCIAL ANXIETY

TD research indicates that individuals with social anxiety differ from those without social anxiety in terms of how they distribute their attention to face stimuli, as well as non-face stimuli, though the underlying, top-down mechanism by which attention is moderated is likely complex (Berggren, & Derakshan, 2013). Nevertheless, research has shown that adults diagnosed with social anxiety exhibit fewer and shorter fixations to relevant facial features (eyes, nose, and mouth) and increased scanpath lengths between fixations (i.e., hyperscanning) compared to control adults (Horley, Williams, Gonsalvez, & Gordon, 2003, 2004). However, it is important to note that these findings may not generalize to elevated social anxiety symptoms in nonclinical, adult samples (Wieser, Pauli, Alpers, & Mühlberger, 2009).

Currently, only one study has assessed the relationship between social anxiety and visual attention to static faces in individuals with ASD (Corden et al., 2008). Interestingly, among individuals with ASD, self-reported social anxiety was negatively correlated with time spent fixating the eyes, but not with autism symptoms, suggesting that social anxiety symptoms are distinguishable from autism symptoms. Thus, social anxiety may similarly help explain individual differences in visual attention to faces during interactive contexts.

2.3 TASK DEMANDS

Within TD research examining top-down moderators of gaze, extensive research has explored how a task's cognitive and social demands influence how attention is distributed when viewing dynamic faces (e.g., Doherty-Sneddon, Bonner, & Bruce, 2001; Edelmann & Hampson, 1981).

Although tasks are often cognitively and socially demanding, studies rarely examine both types of demands together. As a result, relevant findings are reviewed separately for each of these demands (but see, Doherty-Sneddon & Phelps, 2005).

2.3.1 Cognitive demands

Although dynamic faces provide a wealth of information during social interactions, the monitoring and processing of facial information is cognitively demanding. As a result, the cognitive load hypothesis suggests that when the cognitive demands of a task are increased, shifts in visual attention to faces occur to compensate for the increased cognitive load (Glenberg, Schroeder, & Robertson, 1998). However, the nature of these shifts depends on whether facial information facilitates or interferes with the task at hand, and thus, two compensatory eye movement patterns have been documented: centralized eye movements and gaze aversion (Glenberg et al., 1998).

During tasks that mainly assess one's ability to process socio-communicative information, such as face recognition or speech comprehension tasks, facial information is highly relevant, and thus, it facilitates task performance. As a result, eye movement patterns become increasingly centralized with a greater number of fixations occurring in the center of faces (i.e., the nose region). It has been suggested that the central vantage point of the nose enables one to maximize the amount of facial information abstracted, as both the eyes and mouth fall within one's peripheral vision (Buchan et al., 2007; Peterson & Eckstein, 2012). For example, Buchan and colleagues (2008) examined the effects of acoustic noise on visual attention to a dynamic face during a speech perception task. Although TD adults exhibited fewer and longer fixations overall when noise was present compared to when noise was absent, they also preferentially attended to the nose region of faces, as indexed by more frequent and longer fixations. Similar shifts in visual attention have been reported when noise is added to emotion recognition tasks that involve dynamic, audiovisual face stimuli (Buchan et al., 2007). Thus, these centralized eye movement patterns in TD individuals seem to reflect a top-down shift in visual attention that may help maximize the amount of facial information abstracted during cognitively demanding tasks. In addition, longer fixations may help reduce the risk of missing important, but brief facial information during saccades (Henderson & Hollingworth, 1999).

In contrast, there is evidence that facial information can hinder one's ability to respond during cognitively demanding, non-visuospatial tasks, such as memory recall or speech planning (Doherty-Sneddon et al., 2001; Glenberg et al., 1998). As a result, it has been suggested that gaze aversion enables one to disregard facial information when it is not relevant or critical for tasks, thereby permitting more cognitive resources to be allocated to the task at hand (Glenberg et al., 1998). Consistent with this proposition, gaze aversion during cognitively demanding tasks appears to be particularly associated with periods of thinking and speaking, rather than periods of listening (Doherty-Sneddon et al., 2001; Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle, 2002). Moreover, TD research suggests that the association between cognitive demands and gaze aversion is robust, as this association has been found for a wide range of tasks (e.g., verbal, arithmetic, episodic memory, autobiographical memory (Doherty-Sneddon et al., 2001; Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, 2005). These findings have also been replicated in children with Williams syndrome, who typically exhibit increased attention to faces relative to TD children (Doherty-Sneddon, Riby, Calderwood, & Ainsworth, 2009). However, it is important to note that the relationship between gaze aversion and cognitively demanding tasks increases with development (Doherty-Sneddon et al., 2002; Doherty-Sneddon, Phelps, & Clark, 2007). Thus, although gaze aversion is commonly used by TD adults in a variety of cognitively demanding contexts, it is not consistently used by young children.

More important, further research has shown that increased gaze aversion during cognitively demanding tasks is functional, as these shifts in visual attention are associated with better performance on tasks. For example, Doherty-Sneddon and colleagues (2009) found that TD children whose performance on a novel task improved over time spent a greater proportion of time averting gaze while thinking compared to children whose performance did not improve. Additional, more direct support is provided by studies that have experimentally assigned participants to different gaze conditions. In these studies, participants who were instructed to avert their gaze or close their eyes consistently performed better than participants who were instructed to look at the experimenter while answering difficult questions (Doherty-Sneddon et al., 2001; Glenberg et al., 1998; Markson & Paterson, 2009; Phelps, Doherty-Sneddon, & Warnock, 2006; Vredeveldt, Hitch, & Baddeley, 2011). Together, these findings indicate that TD individuals exhibit increased gaze aversion when thinking about and answering difficult questions in naturalistic contexts and that these shifts in visual attention facilitate performance.

With regard to individuals with ASD, two recent studies examined the relationship between gaze aversion and task difficulty by manipulating the difficulty of arithmetic questions participants were required to answer (Doherty-Sneddon et al., 2012; Riby et al., 2012). These studies found that both the association between gaze aversion and cognitive demands and the association between gaze aversion and task performance were similar for the autism group and the control group. However, no research to date has examined the relationship between cognitive demands and centralized fixations in individuals with ASD. Indeed, visual attention to the nose region has rarely been examined in the autism literature on face perception. For example, none of the studies that assessed visual attention to dynamic faces specifically examined fixations to the nose region (Bal et al., 2010; Falck-Ytter et al., 2010; Jones et al., 2008; Klin et al., 2002; Nakano et al., 2010; Norbury et al., 2009; Speer et al., 2007), though in two of these studies, the nose was included within the eye region when it was defined (Bal et al., 2010; Jones et al., 2008).

Although there is limited research examining the effects of cognitive demands on visual attention in individuals with ASD, research with TD individuals supports the possibility that cognitive constraints may underlie some of the aberrant patterns of visual attention documented by autism research. In particular, increased cognitive demands may help explain why atypical visual attention is more consistently found during tasks that use dynamic or complex stimuli compared to those that use static or simple stimuli. However, with regard to the use of gaze aversion, it is important to note that although this compensatory strategy is typically employed during tasks in which facial information is not relevant, the utility of facial information for a given task is not always clear (Glenberg et al., 1998). For example, previous research with TD adults found that optimal performance during a face recognition task was achieved after only two fixations (Hsiao & Cottrell, 2008); however despite this, participants on average exhibited more than two fixations during the free-viewing portions of the task (i.e., when their number of fixations was not restricted). As a result, it is possible that some of the fixations observed during face perception tasks are not necessarily during the task, but rather occur while an individual is thinking (e.g., Peterson & Eckstein, 2013a).

If so, some amount of gaze aversion during tasks could actually be functional for individuals with ASD. Because much of the extant research has examined differences in visual attention during face processing tasks that are known to be difficult for individuals with ASD, observed differences in visual attention may be confounded by differences in the cognitive demands experienced by individuals with ASD compared to TD individuals. Thus, it will be important for research to consider whether differences in gaze, including gaze aversion, may be a consequence, rather than a cause of impairments in face perception.

2.3.2 Social demands

Research suggests that the social demands of a task can also influence visual attention to faces in TD individuals. While various social factors, such as intimacy and dominance, have been examined, the current review focuses on the effects of social discomfort on visual attention to faces. As with research on cognitive demands, researchers have examined the relationship between gaze aversion and social discomfort (Aiello, Derisi, Epstein, & Karlin, 1977). Specifically, it has been theorized that gaze aversion in response to social discomfort helps to decrease negative arousal. One way that research has manipulated the social discomfort associated with tasks is by increasing the intimacy level of personal information that individuals are required to verbally disclose during conversation tasks (Baker & Shaw, 1980; Edelmann & Hampson, 1981; Sundstrom, 1978). In particular, prior research has shown that the intimacy of self-disclosures can be increased by varying the content of conversational topics (e.g., asking about romantic relationships compared to hobbies), as well as by varying the emotional intensity or the negative valence of the information individuals are required to disclose (Howell & Conway, 1990).

In general, research with TD individuals suggests that gaze aversion increases as the intimacy level of these self-disclosures (or personal narratives) increases (Abele, 1986; Carr & Dabbs, 1974; Edelmann & Hampson, 1981; Exline et al., 1965; Sundstrom, 1978). For example, TD adults who were asked intimate questions during a structured interview made less eye contact while speaking compared to those who were asked innocuous questions about their hobbies (39.3% vs 49.8%, respectively; Exline et al., 1965). Although interviews differ in many ways from typical, social interactions, similar results have been reported by studies using acquaintance paradigms (Edelmann & Hampson, 1981; Sundstrom, 1978). Unlike interactions during interviews, acquaintance paradigms require both members of a dyad to take turns listening and responding to questions. Using an acquaintance paradigm, Edelmann and Hampson (1981) found that participants who had to discuss intimate topics made less eye contact both while talking and while listening compared to participants who had to discuss non-intimate topics. Moreover, a similar study found that eye contact decreased as participants rated topics as more difficult to discuss and as topic intimacy increased, regardless of whether dyads were composed of friends or strangers (Sundstrom, 1978).

Although acquaintance paradigms are still more structured than everyday interactions, these studies suggest that gaze aversion also increases during more intimate, back-and-forth, social interactions. However, there is some evidence that the relationship between the intimacy of personal narratives and gaze aversion may decrease as social interactions progress (Abele, 1986; Sundstrom, 1978). Moreover, because visual attention in these studies has been manually coded, the existing research on social discomfort provides only a general description of how visual attention to faces changes during socially demanding tasks. Thus, it is unclear whether social discomfort is associated with more subtle changes in visual attention to faces.

To date, no research has examined the relationship between visual attention to faces in individuals with ASD and social discomfort using personal narratives during an interaction; however, in a recent study, gaze aversion was examined while adolescents interacted with an unfamiliar adult (i.e., the experimenter) or a familiar adult (e.g., a parent or teacher; Doherty-Sneddon et al., 2013). Results from this study indicated that the amount of gaze aversion exhibited by the autism group did not differ depending on the two interaction conditions, whereas, in the control group, gaze aversion was greater during the interaction with the experimenter. However, both groups exhibited a similar amount of averted gaze overall. Although findings from this study suggest that individuals with ASD do not use gaze to modulate social demands during an interaction, other types of social demands, such as disclosing personal information, may have a greater effect on gaze. Still, this finding is interesting as proponents of the affective arousal model of autism have argued that direct eye contact has an aversive effect on individuals with ASD (Corden et al., 2008; Dalton et al., 2005; Joseph, Ehrman, McNally, & Keehn, 2008).

3.0 CURRENT STUDY

Although differences in visual attention to faces have not been consistently reported by past research with individuals with ASD, some of the variability in findings may be attributed to methodological differences (e.g., participant demographics, the complexity of the face stimuli, and the task demands). Furthermore, TD research suggests that these differences across studies are likely meaningful, as patterns of visual attention to faces are influenced by top-down processing (Henderson, 2003). In order to better understand face processing impairments in individuals with ASD, it is critical that research treats visual attention as a dynamic behavior, and thus explores when, not if, individuals with ASD exhibit atypical visual attention.

More systematic exploration of how top-down factors influence face processing in individuals with ASD is also important for informing interventions, as increasing eye gaze is commonly targeted by both individual and group treatment modalities. For instance, a better understanding of the social and cognitive factors that contribute to atypical gaze would help guide the development of ABA therapies by clarifying which variables should be incorporated into task analyses and thus, manipulated during subsequent behavioral programming. Furthermore, careful consideration of the effects of cognitive demands on visual attention in individuals with ASD is important for determining whether gaze strategies such as gaze aversion may be functional at times, as TD research and preliminary autism research have shown that gaze aversion can be associated with performance during certain demanding tasks (e.g., Doherty-

Sneddon et al., 2002; Doherty-Sneddon et al., 2012; Riby et al., 2012). Thus, research is needed to clarify the relationship between gaze patterns and a task's social and cognitive demands so that guidance can be provided to parents, educators, and therapists regarding when interventions targeting eye contact should and should not be implemented.

In addition, it is important that face processing is examined using more ecologically-valid, dynamic-interactive stimuli, as even dynamic face stimuli fail to capture the complex, temporally-demanding processing needed during dyadic social interactions (Risko et al., 2012). Studies examining face processing using dynamic stimuli during interactive contexts are critical for developing a more robust model of face processing in individuals with ASD. Moreover, the increased ecological validity associated with these studies will facilitate the translation of basic research findings into clinical applications. Although similar recommendations have been made by past research (e.g., Boraston & Blakemore, 2007; Volkmar, Lord, Bailey, Schultz, & Klin, 2004), very few studies have examined visual attention during social interactions. As a result, it is currently unclear whether patterns of visual attention exhibited by individuals with ASD while viewing static or dynamic faces are similar to those exhibited while viewing dynamic-interactive faces during social interactions.

The current study begins to address these limitations by examining visual attention to faces in adults with ASD during a simulated-live, social interaction (Bailly, Raidt, & Elisei, 2010; Goodacre & Zadro, 2010). In addition, it attempts to clarify *when* individuals with ASD exhibit atypical gaze by exploring potential, top-down effects related to both cognitive and social demands of narrative topics, as well as effects of participant's role during the interaction on visual attention to faces. Specifically, the current study assessed visual attention to faces while participants completed an acquaintance exercise with a confederate via a simulated-live, video-feed. As in typical acquaintance paradigms, participants during the interaction alternated between speaking about personal narrative topics and listening to the confederate’s responses to the same topics (e.g., Gore, 2009; Shaffer, Smith, & Tomarelli, 1982); however, prerecorded videos of the confederate responding and “listening” were used rather than a live video-feed. Although there are limitations to using prerecorded videos, this ensured the confederate’s behavior was consistent across interactions (cf., García-Pérez et al., 2007) and enhanced the accuracy of the eye tracking methodology (cf., Nadig et al., 2010).

Based on the literature reviewed above, narrative topics that varied depending on their associated cognitive and social demands were used during the acquaintance exercise. Modeled after a study by Glenberg and colleagues (1998), cognitive demands were manipulated by varying the type of memory recall needed to respond to narrative topics, with recent memories being easier to recall and less cognitively demanding compared to remote memories. In addition, social demands were manipulated by varying the emotional valence associated with narrative topics, with topics related to neutral or positive personal experiences being less intimate and less socially demanding compared to topics related to negative personal experiences (Howell & Conway, 1990; Snell, Miller, & Belk, 1988). Lastly, individual differences in IQ, autism symptoms, and social anxiety were assessed as potential moderators of visual attention to faces.

Unlike prior research, eye tracking was used to examine visual attention to the confederate’s facial features (eyes, nose, mouth) and face. In addition, several indices of visual attention were examined, including: overall fixation duration (i.e., the total amount of time spent fixating), mean fixation duration (i.e., the average time spent fixating before exhibiting a saccade), and mean scanpath distance (i.e., average distance between fixations). Although these measures of visual attention are correlated in TD individuals, there are subtle differences among them. Specifically, overall fixation duration assesses the allocation of visual attention, mean fixation duration assesses the speed of visual processing, and mean scanpath distance assesses the breadth of visual encoding (Karatekin, 2007). Finally, temporal-specific differences in visual attention were described using a frame-by-frame analytic approach (Nakano, et al., 2010).

Based on the research reviewed, it was hypothesized that:

1) Relative to TD adults, adults with ASD would exhibit atypical visual attention when viewing dynamic, audiovisual videos of the confederate, but not when viewing a static picture of the confederate.
2) All participants would spend more time fixating the eyes when listening compared to speaking.
3) Adults with ASD would spend less time fixating the confederate's eyes compared to TD adults.
4) For all participants, the overall time spent fixating the eyes would decrease when social demands of narrative topics are increased, regardless of whether participants are listening or responding during the interaction. Thus, both groups would exhibit increased gaze aversion when disclosing memories that have a negative valence and when listening to the confederate talk about negative experiences. However, it was predicted that the magnitude of this increase in gaze aversion would be less in adults with ASD compared to that in TD adults.
5) Similar to the effects of social demands, all participants would fixate on the eyes less when the cognitive of narrative topics are increased; however, it was predicted that this effect would be unique to portions of the interaction when participants were responding. Thus, both groups would exhibit increased gaze aversion when asked to disclose memories that were remote, but not when listening to the confederate's responses to topics with high cognitive demands.

Again, it was predicted that the magnitude of this increase in gaze aversion would be less in adults with ASD compared to that in TD adults.

6) Among TD adults, eye movements would become more centralized (e.g., increased fixations to the nose and decreased scanpath distances), but only when responding to cognitively demanding topics. Because of the exploratory nature of this analysis, no specific hypotheses were proposed for adults with ASD.

4.0 METHOD

The current study employed a 2 (Group) x 2 (Participant's Role) x 2 (Cognitive Demands) x 2 (Social Demands) design, with participant's role and the cognitive and social demands of topics as repeated measures variables. The study's procedure consisted of three parts: the screening phase of the "Get Acquainted" exercise, the interaction phase of the "Get Acquainted" exercise, and the post-interaction phase. During the screening phase, participants were shown static photographs of three different adult males in succession and told that the photographs depicted other participants whom they might be assigned to interact with during the "Get Acquainted" exercise. The screening phase served two functions: 1) to decrease the likelihood of participants suspecting that their partner was a confederate and that the interaction was not live, and 2) to provide eye movement data when viewing a static image of the confederate that could be compared to eye movement data collected during the social interaction. Afterward, during the interaction phase of the "Get Acquainted" exercise, participants participated in a simulated interaction with the confederate using an acquaintance paradigm. Additional credibility cues were provided during the interaction to further reduce any suspicion regarding the experimental procedure. Lastly, during the post-interaction phase, participants completed questionnaires that assessed their perception of the interaction (i.e., Post-Interaction Questionnaire) and their self-reported, social anxiety symptoms (i.e., Social Phobia and Anxiety Inventory-23; Roberson-Nay, Strong, Nay, Beidel, & Turner, 2007).

4.1 PARTICIPANTS

Nineteen adults with high-functioning autism and 19 TD adults between the ages of 18 and 42 years old were recruited from a pool of participants who previously participated in research studies associated with the Pittsburgh Autism Center for Excellence (ACE) at the University of Pittsburgh. Participants in the autism group and the control group were matched on chronological age, verbal IQ (VIQ), performance IQ (PIQ), full scale IQ (FSIQ), and social anxiety symptoms (see Table 1). No significant differences were found between the two groups on any of the matching variables (ps>.05). Although no restrictions were placed on participant demographics (gender, ethnicity, SES) during initial recruitment, the current study included only male participants as differences may exist between same-sex and opposite-sex, dyadic interactions.

Table 1. Participant Matching Characteristics

	Control Group (*n*=19)		Autism Group (*n*=19)	
Variable	*M*	*SD*	*M*	*SD*
Age	28	6.93	27.37	7.11
VIQ	112.95	8.39	110.84	14.55
PIQ	114.58	8.53	111.42	16.91
FSIQ	115.58	10.76	112.84	16.33
SPAI-23	16.47	9.14	20.16	7.94

Note. VIQ=Verbal IQ; PIQ=Performance IQ; FSIQ=Full Scale IQ; SPAI-23= Social Phobia and Anxiety Inventory–23 Difference Score.

Participants were initially recruited from the greater Pittsburgh area using posters, newspaper and radio advertisements, and flyers. In order to be eligible for prior studies, participants were required to have average intelligence (i.e., FSIQs>80), as determined by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) and to be in good medical health. For participants in the autism group, diagnoses were confirmed using the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994), the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000), and expert clinical opinion. Participants in the autism group were excluded if they had been previously diagnosed with a known genetic disorder. Mean ADOS communication, social, and combined (communication + social) scores, as well as mean Social Responsiveness Scale (SRS; Constantino & Gruber, 2005) scores for participants in the autism group are shown in Table 2. However, as can be seen in Table 2, SRS scores were only available for a subset of participants.

Table 2. Diagnostic Characteristics for Participants in the Autism Group

Measure	*n*	*M(SD*)	Range
ADOS Com.	19	3.63 (1.17)	2-6
ADOS Soc.	19	7.89 (2.51)	5-13
ADOS Com.Soc.	19	11.53 (3.36)	7-18
SRS (*t*-scores)			
Social Awareness	11	66.91 (12.65)	52-88
Social Cognition	11	75.27 (13.44)	52-99
Social Communication	11	79.18 (14.01)	47-96
Social Motivation	11	75.73 (11.23)	54-90
Autism Mannerisms	11	83.18 (18.63)	51-103
Total	11	80.91 (13.35)	53-99

Note. ADOS Com. = ADOS Communication Score; ADOS Soc. = ADOS Social Score; ADOS Com.Soc.= ADOS Combined Score (Communication + Social); SRS=Social Responsiveness Scores.

Participants in the control group were required to have a negative lifetime history for psychiatric and neurologic disorders. In addition, control participants were required to have a negative family history for any pervasive developmental disorders in first and second degree relatives and for any psychiatric disorder in first degree relatives, as assessed using the Family History Screen (Weissman et al., 2000). Control participants were also excluded if they had a history of: significant problems during prenatal or perinatal periods, significantly delayed developmental milestones, loss of consciousness, or truancy. Lastly, control participants were excluded if a learning disability was suspected based on discrepancies between IQ and achievement, as assessed by the Wide Range Achievement Test-IV (WRAT4; Wilkinson & Robertson, 2006).

It is also important to note that three participants were recruited for the current study, but not included in any analyses. Excluded participants included: a female participant with ASD who was excluded because of gender, a male participant with ASD who was excluded because an accurate calibration was not able to be obtained, and a male, TD participant who was excluded because of clinical concerns regarding his behavior.

All participants in the current study were European-Americans. As shown in Table 3, the majority of participants in both the autism group and control group were employed, single, and had at least some college education. In addition to these demographics, information was collected related to participants' prior experience using video-mediated communication and prior involvement in a social skills intervention. Twice as many participants in the control group reported having used video-mediated communication, such as Skype, compared to the autism group (n=12 vs. n=6, respectively). Among the autism group, 11 participants reported having previously participated in a social skills intervention, and nearly all of these participants reported having been instructed to "look at the eyes" or make eye contact during social interactions (n=10). In contrast, no participants in the control group reported having participated in a socials skills intervention.

Table 3. Participant Demographics

Measure	Control (n=19)	Autism (n=19)
Employment Status		
Employed:Unemployed Ratio	18:1	15:3
Marital Status		
Single:Married Ratio	18:1	18:1
Education (n)		
Some High School	0	1
High School	1	3
Some College or College Degree	15	12
Graduate School	2	2
Unknown	1	1
Prior experience[1] with VMC	12	6
VMC used to communicate with:		
Friends/Family	7	5
Co-workers	1	0
Both	4	1
Prior participation in a social skills intervention	0	11

Note. VMC=Video-Mediated Communication, such as Skype.
Footnote[1] Participants who reported prior experience with VMC reported having used it on at least 4-6 occasions.

4.2 MEASURES

4.2.1 Post-Interaction Questionnaire

The Post-Interaction Questionnaire consisted of 18 items adapted from Gore (2009) designed to assess participants' suspicion concerning the task, perception of the confederate (i.e., the confederate's likeability and responsiveness), and overall perception of the interaction. Three additional items were added to evaluate participants' perception of video-mediated communication compared to face-to-face communication (see Appendix A). Responses to items used a 5-point Likert scale, with higher ratings indicating greater agreement with the item. Specifically, Question 19 ("Aside from talking to a stranger in a lab setting, this interaction did not seem unusual") was examined as a suspicion check. Responsivity was examined by aggregating scores from Questions 1, 5, 6, 13, and 15 and reverse scores from Questions 3 and 16, and likability was examined by aggregating scores from Questions 4, 8, 10, 11, and 17.

4.2.2 Social Phobia and Anxiety Inventory–23 (SPAI-23)

Social anxiety was assessed using the abbreviated form of the Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, & Dancu, 1996), the SPAI-23 (Roberson-Nay et al., 2007). The SPAI-23 consists of 23 items that assess somatic, cognitive, and behavioral symptoms experienced during a variety of social contexts and contains two subscales (social phobia and agoraphobia). The SPAI-23 has excellent reliability when used to screen for social phobia in adults (alpha = .95; Roberson-Nay et al., 2007). Social anxiety symptoms were assessed using a difference score, in which the agoraphobia subscale score is subtracted from the social phobia subscale score, as this provides the best discriminate validity when assessing social phobia in clinical samples (Roberson-Nay et al., 2007). Greater difference scores reflect greater social anxiety symptoms, and scores greater than 29 are suggestive of clinically significant symptoms.

4.2.3 Social Responsiveness Scale (SRS; Constantino & Gruber, 2005)

Autism symptomatology was assessed for a subset of participants in the autism group (n=11) using the SRS. The SRS is a 65-item, parent-report questionnaire that assesses the severity of social impairments in individuals with ASD. The SRS demonstrates good internal consistency (alphas > .9), interrater reliability (r = .79-.91), and test-retest reliability (r=.81-.88).

4.3 STIMULI AND MATERIALS

4.3.1 Narrative topics for the "Get Acquainted" exercise

Narrative topics that varied in both their social and cognitive demands were created to elicit autobiographical self-disclosures during the "Get Acquainted" exercise**.** A pool of 24 questions were created by modifying 12 topics chosen from The Ungame, a therapeutic question-answer game designed to facilitate social sharing and listening skills (see Appendix B). Six of the unmodified topics were considered to have *low social demands*, as they pertained to either neutral or positive emotional experiences. The remaining six unmodified topics pertained to negative emotional experiences and were considered to have *high social demands*.

Each of these topics was then modified to create both a *low cognitive demands* version and a *high cognitive demands* version. For low cognitive demands versions, topics were modified so that they specifically asked about experiences within the past year, whereas, for high cognitive demands versions, topics were modified so that they specifically asked about childhood experiences. Thus, the social demands for topics were crossed with the cognitive demands, producing four experimental topic conditions, those with: low social and low cognitive demands (*low-low topics*), high social and low cognitive demands (*high social topics*), low social and high cognitive demands (*high cognitive topics*), and high social and high cognitive demands (*high-high topics*). After the cognitive and social demands for narrative topics were crossed, the modified set of topics included six topics within each experimental topic condition.

For each of the four experimental topic conditions (low-low, high cognitive, high social, high-high), three modified topics were randomly selected for the "Get Acquainted" exercise; however, only one modified version of a topic (i.e., low or high cognitive demands) was included so that there would be no overlap among narrative topics in terms of what type of personal experience participants were asked to disclose. The order in which topics were presented was standardized across participants; however, the order of topics was determined using block randomization to minimize any potential order or sequence effects. Furthermore, an additional topic that was not analyzed during the current study was presented first, to control for any practice effects and to ensure participants understood the format of the interaction phase of the "Get Acquainted" exercise. This practice topic differed from experimental topics in both the nature of its cognitive and social demands, as it directed participants to talk about a future event and did not direct participants to disclose personal or intimate information.

4.3.2 Screening phase stimuli

Screening phase stimuli included three photographs of unfamiliar, adult males with neutral facial expressions, consisting of two fictitious participants (Actor 1 and Actor 2) and the confederate. The inclusion of fictitious participants served to reduce any suspicion concerning the confederate's identity. Photographs depicted individuals from the shoulders up, standing in front of neutral backgrounds. Screening phase stimuli were presented one at a time in a fixed order and remained on the screen until the participant verbally indicated whether he recognized the individual depicted.

4.3.3 Interaction phase stimuli

Prerecorded videos of a male confederate responding to the "Get Acquainted" exercise topics and "listening" were presented during the interaction phase to simulate a live, video-mediated interaction. Videos depicted the confederate in an environment similar to the testing booth used by actual participants and care was taken to ensure that a similar amount of the confederate's body was visible in the videos. For the videos of the confederate listening (i.e., the stimuli presented during the portions of the interaction in which the participant responded), the confederate was instructed to make eye contact approximately 60-70% of the time. He was also informed that he did not need to sit completely still, and could fidget, change posture, or gesture. However, for the videos of the confederate responding (i.e., the stimuli presented during the listening portions of the interaction), the confederate was not given any direction regarding his nonverbal behavior, nor was he provided direction on the content of his responses, other than to not reference specific days, times, or events that would allow participants to make inferences about when the videos were recorded (e.g., the confederate was asked to not mention seeing a specific movie, as any movie named may not be current when the videos were viewed). Although the confederate was aware that the study was designed to look at face processing during a simulated interaction, he had no knowledge regarding the rationale for the selection of narrative topics or any of the experimental hypotheses.

4.4 APPARATUS

Eye movement data were recorded using a Tobii X120 Eye Tracker. The Tobii X120 is a free-standing, non-invasive eye tracker that assesses visual attention based on changes in pupil-corneal reflection. The eye tracker is capable of detecting small changes in visual attention that are greater than .5°, and eye movement data are sampled at a rate of 60 Hz. The eye tracker was positioned on a desk between the screen and the participant. A 9-point calibration was completed prior to the study and the calibration procedure was repeated as necessary until a satisfactory calibration was obtained. An additional camera was set up on a tripod near the eye tracker, which allowed the experimenter to monitor the participant’s behavior during the interaction. This camera also served as a credibility cue, as participants were told that it was needed to provide a live video-feed during the interaction.

4.5 PROCEDURE

Upon arrival to the lab, the experimenter provided participants with a general overview of the study. Because the interaction was simulated, it was necessary to conceal the true purpose of the experiment. As a result, a cover story was created to provide a rationale for the study and for various aspects of the procedure. Specifically, participants were told that the current study was designed to examine the use of video chatting technology, such as Skype, during initial interactions between two recently acquainted individuals, and in particular, whether this technology made it easier or harder to get to know someone. The experimenter then told participants that they would be participating in a "Get Acquainted" exercise with another male participant using a live video-feed. They were told that the "Get Acquainted" exercise involved taking turns volunteering information about personal experiences related to a variety of topics and was designed to help them get to know another participant. However, the experimenter informed participants that they could decline to discuss any topics which would make them feel uncomfortable.

The experimenter also explained to participants that because the study was interested in interactions between newly acquainted individuals, they would first be shown pictures of the other participants (i.e., screening phase) to ensure that they were matched with someone who was unfamiliar. Similarly, participants were informed that their picture would also need to be taken so that it could be shown to the other participants. Participants were reassured that their picture would not be used for any other purpose and that no identifying information would be shared with other participants. Lastly, the experimenter indicated that participants would be randomly matched with an unfamiliar participant who would be their partner during the interaction. Following this overview, participants were provided with an opportunity to ask questions and consent to participate in the study was obtained.

After obtaining consent, the experimenter provided participants with the following specific instructions: during the "Get Acquainted" exercise, you and your partner will take turns talking about topics that will appear on the screen. Each topic will appear twice. Once at the beginning and then again as a reminder after the first person has finished responding. There will be 13 topics in total, and the interaction will last approximately half an hour. The computer will randomly select who will respond first to questions. The first person will respond to the topic and then listen as his partner responds to the same topic. During the exercise, we ask that you listen quietly while your partner is talking and do not interrupt. Each person will be allowed up to 50 seconds to respond to the topic. After 40 seconds have elapsed, you will hear a beep indicating that your time is nearly up. After 50 seconds have elapsed, you will hear another beep indicating that your time is up and the next topic will appear.

After the instructions for the "Get Acquainted" exercise were provided, participants were reminded that they could decline to answer any topic by simply stating that they would like "to pass." Participants were told that after completing the "Get Acquainted" exercise, they would be asked to fill out questionnaires concerning their thoughts and feelings about the interaction and about social interactions more generally. After going over the instructions for the task, participants were provided with another opportunity to ask questions. After addressing any questions or concerns regarding the task, the experimenter asked participants to stand in front of a white wall so that his picture could be taken for the screening phase. After taking the participant's picture with a digital camera, the experimenter indicated that he or she was going to upload the participant's picture and that it would be a few minutes before all participants were ready and the experiment could begin. The experimenter then left the waiting room and immediately deleted the participant's photograph.

After several minutes had passed, the experimenter brought the participant into the testing booth, where he was seated approximately 150 cm from the rear projection screen. Once comfortably seated, the experimenter asked the participant to be relatively still during the interaction to ensure that he remained visible at all times, and the calibration procedure was completed. Prior to beginning the experiment, the experimenter briefly reviewed the task instructions and provided the participant with another opportunity to ask.

4.5.1 Screening phase

During the screening phase, the three screening phase stimuli were presented one at a time (see Figure 1). For each stimulus, the experimenter asked whether the participant recognized the individual depicted. After viewing all three screening phase stimuli, an animated graphic was shown on the screen to simulate the computer processing the participant's responses and matching him to another, unfamiliar participant, though the confederate was always selected as the participant's partner. Afterward, participants were shown a picture of their selected partner (i.e., the confederate) and told that they were assigned to be Participant 1, indicating that they would respond first to each topic.

The following procedure was created in the unlikely event that a participant indicated he recognized any of the screening phase stimuli, though it was not needed during the current study as no participant reported knowing the confederate or either of the two actors. According to the procedure, the experimenter was to query whether the participant recognized the individual's face or had actually spoken to the person before. If the participant denied knowing the confederate, regardless of whether he knew either of the two fictitious participants, the "Get Acquainted" exercise would proceed as planned. However, if a participant reported that he had previously spoken to the confederate, the experimenter was to terminate the study and debrief the participant.

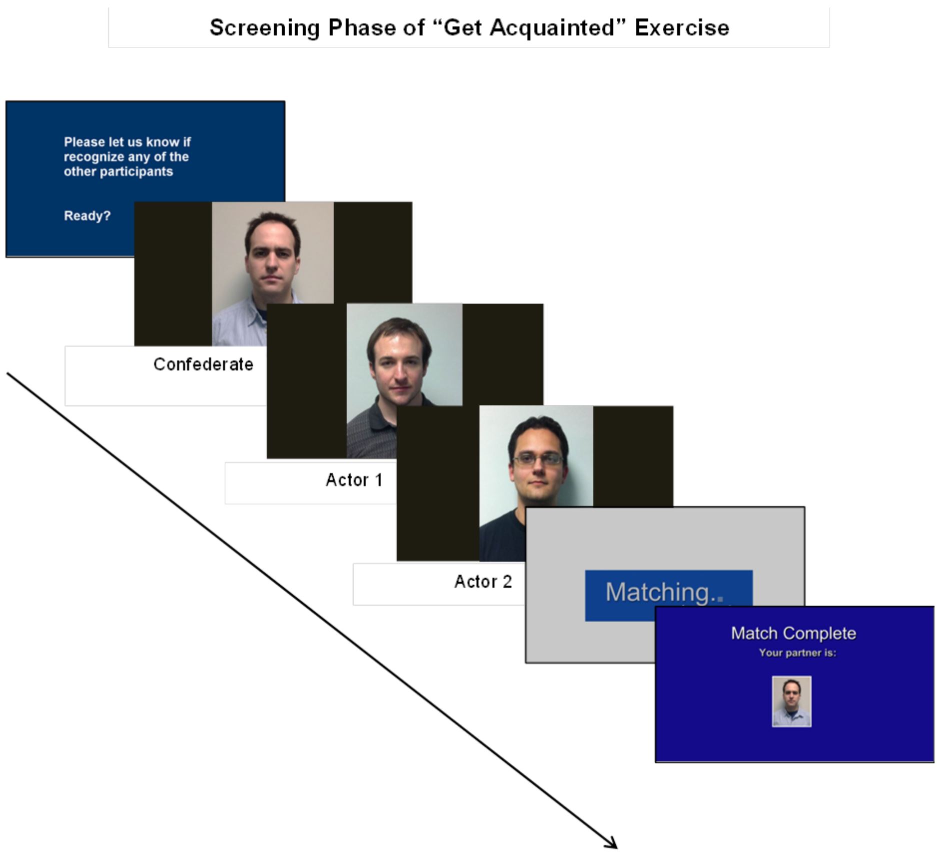

Figure 1. Snapshots of the screen during the "Get Acquainted" exercise depicting the sequence of events during the screening phase.

4.5.2 Interaction phase of the "Get acquainted" exercise

After completing the screening phase, the experimenter informed participants that because a live video-feed was being used, there could be delays in video transmission. This explanation was provided to explain any instances in which there appeared to be a delay in the confederate's verbal or nonverbal behavior. The experimenter then left the testing booth to set up the simulated video chatting program. As a credibility cue, the experimenter projected a pre-recorded video of a computer screen that depicted someone logging on to a video conferencing program while making keystrokes on the keyboard to simulate typing. As a loading graphic was displayed on the screen, the experimenter re-entered the testing booth. When the loading graphic disappeared, another pre-recorded video was displayed on the screen depicting the participant's partner, as well as another male confederate posing as an experimenter. The experimenter then repeated a rehearsed dialogue directed at the experimenter visible on the screen (e.g., asking the other experimenter to adjust the volume in the other testing booth), which was carefully timed in relation to the fake experimenter's verbal and nonverbal behavior (e.g., experimenter adjusted the volume) in order make it appear as if he was responding.

After the fake experimenter appeared to exit the video screen, the experimenter repeated parts of the task's instructions as if he or she was speaking to both the participant and the confederate. As additional credibility cues, the experimenter prompted the participant and confederate to say "hi" to each other, timed such that the confederate appeared to wave after being introduced, and asked questions (e.g., "Are you ready?") that were timed such that the confederate appeared to shake his head in response. Afterward, participants were provided with a final opportunity to ask any questions or express any concerns. Following this initial setup, the first topic was presented on the screen for 15 seconds. Immediately following the topic, a prerecorded video of the confederate listening was shown while the participant responded. After the participant finished responding, the topic was presented again for 15 seconds, followed by a video in which the confederate responded. The same sequence was repeated for the remaining 12 topics (see Figure 2 for a summary of the steps during the interaction phase).

4.5.3 Post-interaction phase

Following the “Get Acquainted” exercise, participants completed the Post-Interaction Questionnaire and the SPAI-23. In addition to these measures, participants were asked to rate both the importance of eye contact during social interactions and their skill at making eye contact, using a 5-point Likert scale, in which higher scores indicated greater importance or skill, respectively. Following this, the experimenter debriefed participants regarding the true nature of the study.

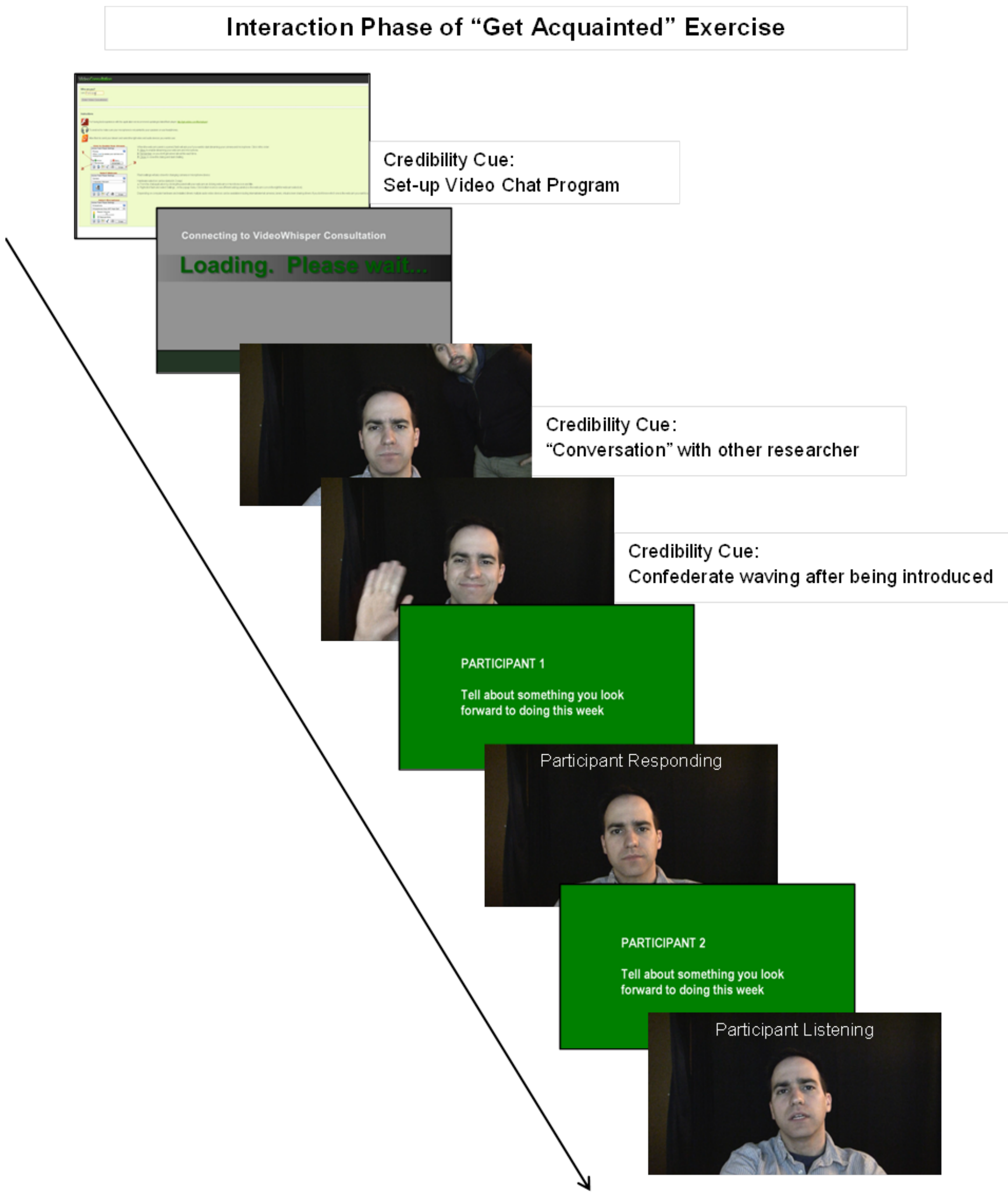

Figure 2. Snapshots of the screen during the "Get Acquainted" exercise depicting the sequence of events during the interaction phase.

5.0 ANALYTIC STRATEGY

5.1 DATA REDUCTION

5.1.1 Areas of interest

Differences in visual attention were examined for several predefined areas of interests (AOIs). Separate AOIs were created for each facial feature (eyes, nose, and mouth), the entire face, and the entire video screen frame. The size and shape of each AOI was held constant across all stimuli, including the static stimulus of the confederate used during the screening phase, to ensure that differences in visual attention were not confounded by variations in the area encompassed by a given AOI (as larger AOIs could affect the likelihood of fixations occurring within its boundaries). With the exception of the Mouth AOI, AOIs were drawn using a still video frame of the confederate with a full-face view, in which the confederate was oriented directly toward the camera and had a neutral expression. Because the size of the confederate's mouth varied as he was speaking, the Mouth AOI was drawn using a still frame of the confederate taken mid-vocalization when his mouth was fully open.

The size of the Eyes AOI was determined by drawing a rectangle that extended vertically from the top of the eyebrows to just below the eye and horizontally from the left-most portion of the left eyebrow to the right-most portion of the right eyebrow. The Nose AOI was drawn as a rectangle that extended vertically from just under the Eyes AOI to just below the bottom of the nostrils and horizontally from the left-most portion of left nostril to the right-most portion of the right nostril. The Mouth AOI was drawn as a rectangle that extended vertically from the upper and lower boundaries of the confederate's mouth while speaking and horizontally from the left-most corner of the month to the right-most corner of the mouth. The Face AOI was drawn as an oval that extended vertically from the apex of the confederate's forehead to the bottom of the confederate's chin and horizontally from the left-most portion to the right-most portion of his face (excluding his ears and hair). The Screen AOI was drawn as a rectangle that included the entire video screen. The resulting AOIs subtended a visual angle of 6.52 º x 2.16 º for the confederate's eyes, 2.39 º x 1.77 º for the confederate's nose, 4.14 º x 1.98 º for the confederate's mouth, and 8.26º x 12.74 º for the confederate's entire face. The screen subtended a visual angle of 41.22 º x 25.00 º.

Figure 3. Example frames depicting the location of AOIs. Eye AOI shown in purple; Nose AOI shown in pink; Mouth AOI shown in orange; Face AOI shown in blue.

The position of AOIs for each facial region was manually adjusted to account for changes in vertical, horizontal, and rotational location of facial regions on a frame-by-frame basis for each video using predefined criteria to anchor their placement. Example frames depicting the location of AOIs are shown in Figure 3. Specifically, the outer vertical and horizontal boundaries of the eyebrows were used to adjust the position of the Eyes AOI; the vertical and horizontal boundaries of the nostrils were used to adjust the position of the Nose AOI; the Mouth

AOI was centered based on the horizontal-most and vertical-most boundaries of the mouth; finally, the apex of the forehead was used to adjust the position of the Face AOI (see Figure 3).

5.1.2 Calculation of indexes of visual attention

Four measures of visual attention were examined in the current study: total fixation duration, mean fixation duration, mean scanpath distance, and frame-by-frame viewing proportion.

5.1.2.1 Total fixation duration

For total fixation duration, scores were standardized across participants by viewing duration (i.e., the duration in which stimuli were presented and able to be viewed by participants) to determine the percentage of time spent fixating an AOI. Percentages were calculated separately for the Eyes, Nose, Mouth, and Face AOIs by dividing the overall fixation duration in seconds for an AOI across a given set of stimuli (e.g., all videos of the confederate responding to Low-Low topics) by the overall viewing duration for the same set of stimuli and then multiplying this proportion by 100. Thus, four measures of the total fixation duration were calculated: percentage of time spent fixating the Eyes AOI (%Eyes), percentage of time spent fixating the Nose AOI (%Nose), percentage of time spent fixating the Mouth AOI (%Mouth), and percentage of time spent fixating the Face AOI (%Face). Total fixation durations were calculated for each AOI using the Tobii Studio's statistical software.

5.1.2.2 Mean fixation duration

The mean fixation duration was calculated by averaging the duration of all fixations within the Face AOI. More specific calculations were not possible for facial features as not all participants fixated each AOI for every stimulus, resulting in many participants being excluded from analyses because of missing data. As with total fixation durations, Tobii Studio's statistical software was used to calculate the mean fixation durations.

5.1.2.3 Mean scanpath distances

Mean scanpath distances were extracted from raw fixation data using a custom Matlab script that calculated the Euclidian distance in pixels between each pair of sequential fixations within a stimulus, using the x and y coordinates of fixation points. These distances were then averaged across a stimulus to determine the mean scanpath distance (Horley, et al. 2003; Horley et al, 2004). However, it was not possible to export the coordinates of AOIs drawn using Tobii Studio's software, and thus it was not possible to calculate mean scanpath distances within specific AOIs.

5.1.2.4 Frame-by-frame viewing proportion

For frame-by-frame analyses, viewing proportions (i.e., the proportion of participants viewing a given AOI; Nakano, et al., 2010) were also calculated using custom, Matlab script to process raw fixation data that had been exported using Tobii Studio's software. The raw fixation data included a log of the following data at each time point sampled by the eye-tracker: 1) studio events, which indicated when stimuli were presented, 2) fixation index, which provided an incremental count of fixations, and 3) AOI hits, which reported if a fixation occurred within an AOI. These data provided general information about the location of a fixation, based on the AOI in which it occurred, as well as the specific time in which a fixation occurred. As mentioned above, it was not possible to export the coordinates of AOIs, and thus, it was not possible to determine more precisely where a participant was looking within an AOI using raw fixation coordinates.

In order to calculate frame-by-frame viewing proportions, fixation data were binned over 333 milliseconds intervals. This time interval was selected because it was large enough to allow for independent sampling among data points (i.e., long enough to permit a shift in fixation locations between consecutive data points, as research indicates that fixations typically last between 200 and 300 ms; Buchan, Paré, & Munhall, 2008), yet was small enough to identify temporal-specific changes in gaze. For every bin, a participant was classified as either viewing or not viewing an AOI, regardless of whether or not the participant fixated the AOI for the entire duration of the time interval in which data were binned. The viewing proportion for each AOI was then calculated separately for the autism group and the control group, by dividing the number of participants fixating an AOI by the total number of participants. However, it is important to note that because transitions between fixations could occur within a bin, a participant could be classified as fixating more than one AOI for a given bin. As a result, it was possible for the sum of viewing proportions to the eyes, nose, and mouths to exceed 1.

6.0 DATA ANALYSIS

6.1 PRELIMINARY ANALYSES

Prior to examining patterns of visual attention during the experimental task, preliminary analyses were conducted to assess whether between-group differences existed with respect to: Post-Interaction Questionnaire ratings, viewing durations of stimuli (i.e., duration of time, determined by a participant's responses, in which a stimulus was presented and able to be viewed), and overall duration of visual attention to stimuli (i.e., duration of time in which a participant actually fixated the stimulus). These preliminary analyses were included to assess whether any differences in the distribution of visual attention to facial features could be confounded by underlying differences in participants' perception of the confederate and interaction task (suspicion check rating and ratings of the confederate's responsiveness and likability), the duration in which stimuli were able to be viewed, or overall differences in the duration of visual attention during the experimental tasks.

For the Post-Interaction Questionnaire, a Mann-Whitney *U* test was used to examine between-group differences in suspicion check ratings (i.e., ratings for Question 19: "Aside from talking to a stranger in a lab setting, this interaction did not seem unusual"). Mann-Whitney *U* tests were also used to examine between-group differences in mean ratings of the confederate's responsiveness and likability. For viewing duration and overall duration of visual attention, paired *t* tests were used to examine differences between groups for the static stimulus of the confederate during the screening phase and both types of dynamic stimuli of the confederate used during the interaction phase. In addition to these analyses, participant ratings regarding the importance of eye contact and self-reported skill at making eye contact were compared for the two groups using Mann-Whitney *U* tests.

6.2 **PRIMARY ANALYSES**

Separate mixed design ANOVAs were conducted for the following indexes of visual attention: proportion of time spent fixating, mean fixation duration, and scanpath distances. However, for the proportion of time spent fixating, visual attention to each AOI was treated as a separate dependent variable. For post-hoc analyses, FDR corrections were used to control for Type 1 error resulting from these multiple comparisons.

6.2.1 Effects of stimulus type on visual attention (Hypothesis 1)

To address Hypothesis 1, patterns of visual attention were compared across three types of stimuli: 1) a static stimulus of the confederate viewed during the screening phase 2) a dynamic, audiovisual stimulus of the confederate viewed during the listening condition (Dynamic-Listening) and 3) a dynamic, visual stimulus of the confederate viewed during the responding condition (Dynamic-Responding). For both dynamic stimuli, measures of visual attention were examined for only the low-low topic conditions, as the purpose of these analyses was to compare how the complexity of the face stimulus viewed affected patterns of visual attention, apart from any additional effects resulting from the cognitive or social demands of topic conditions. Thus, parallel, mixed design 2 x 3 ANOVAs with group (control, autism), a between-subjects variable, and stimulus type, static, Dynamic-Listening, Dynamic-Responding) a within-in subjects variable, were conducted to examine differences in the percentage of time spent fixating and the mean fixation duration.

6.2.2 Effects of participant's role and topic demands on visual attention (Hypotheses 2-6)

To address Hypotheses 2 through 6, patterns of visual attention, as indicated by the percentage of time spent fixating on AOIs, the mean fixation duration, and the mean scanpath distance, were examined during the interaction phase of the experiment to evaluate the effects group, participant's role, topic demands (cognitive and social). For each index of visual attention, a 2 (Group) X 2 (Participant's Role) X 2 (Cognitive Demands) x 2 (Social Demands) mixed design ANOVA was conducted. In all analyses, group was a between-subjects variable and the remaining variables were within-subjects variables.

6.2.3 Planned contrasts for primary analyses

Based on the literature reviewed, several specific predictions were made to evaluate Hypotheses 1-6.

1a. The autism group would spend a smaller percentage of the time fixating the confederate's face when viewing a Dynamic-Listening stimulus, whereas no differences between groups in % Face would exist when viewing a static stimulus (Hypothesis 1).

1b. The autism group would exhibit longer mean fixation durations when viewing a Dynamic-Listening stimulus compared to the control group (Hypothesis 1).[2]

2. For both groups, participants would demonstrate an increase in %Eyes when listening compared to responding (Hypothesis 2).

3. The autism group would spend a smaller percentage of time fixating the eye region compared to the control group, irrespective of participant's role or topic demands (Hypothesis 3).

4. For each group, the % Eyes would be less *both* when responding and when listening to *high social topics* with compared to *low-low topics*. However, it was expected that this relative decrease in %Eyes would be attenuated in the autism group (Hypothesis 4).

5. Participants would demonstrate a decrease in the % Eyes when responding to *high cognitive topics* compared to *low-low topics*. Contrary to the predicted effect of social demands, it was expected that this relative decrease in %Eyes would be similar for the two groups (Hypothesis 5).

6. In contrast, the %Nose would be greater when participants were responding to *high cognitive topics* compared to *low-low topics*. It was expected that this relative increase in %Nose would be greater for the control group (Hypothesis 6).

7. Participants would also exhibit shorter mean scanpath distances when responding to *high cognitive topics* compared to *low-low topics* (Hypothesis 6).

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[2] For the Dynamic-Responding stimulus, it seemed plausible that between-group differences could be less pronounced than those expected for the Dynamic-Listening condition because this type of stimulus lacked audio, and thus, could be considered less perceptually complex. However, an alternative possibility was that between-group differences could be greater, as even though the cognitive and social demands were minimized in the low-low condition (relative to the other responding portions of the interaction), that the act of speaking still increased the complexity of the task. As a result, no specific predictions were made for the Dynamic-Responding stimulus condition.

In addition to these hypothesis specific predictions, two additional, general predictions were generated based on the literate reviewed.

8. Individuals with ASD have well documented difficulties on face recognition and perception tasks, and difficulties on these tasks are thought to reflect underlying impairments in face processing. Although there is some disagreement as to whether individuals with ASD employ different information processing strategies or are biased toward processing certain kinds of information (i.e., featural), either of these possibilities would be associated with less efficient face processing. Because fixation durations provide an index of how quickly information is processed, it was predicted that the autism group would demonstrate longer mean fixation durations during the interaction compared to the control group.
9. Although there is a paucity of research linking information processing strategies with eye movement patterns, it seems plausible that the type of information processing used during the task would be associated with differences in the mean scanpath distance. Because configural processing of faces may be associated with increased across-feature fixations (Bombari et al., 2009) and more distributed attention (Schwarzer et al., 2005) compared to featural processing, it was predicted that relative increases in mean scanpath distances would reflect a greater emphasis on configural information. Conversely, it was predicted that relative decreases in mean scanpath distances would reflect a greater emphasis on featural information. Thus, in terms of group differences, it was predicted that participants in the autism group would demonstrate shorter mean scanpath distances compared to those in the control group, reflecting a bias toward featureal information.

6.3 ANALYSIS OF INDIVIDUAL DIFFERENCES IN VISUAL ATTENTION

Pearson's correlations matrixes were calculated to examine whether differences in IQ (FSIQ, VIQ, and PIQ) and social anxiety (SPAI-23 difference score) could account for variability in measures of visual attention across participants. In addition, for the autism group, the relationship among indexes of visual attention and individual differences in autism symptomology were examined. Autism symptomology was assessed using the ADOS Communication Score, Social Score, and Combined Score (Communication + Social). For a subset of participants in the autism group, SRS Total Score was also examined.

In terms of visual attention, only the percentage of time spent fixating the confederate's face, the mean fixation duration to the confederate's face, and the mean scanpath distance were examined for these analyses, though each measure was examined separately depending on the participant's role (listening vs. responding). Each of the resulting six indexes of visual attention was calculated using data from low-low topics only. Because these analyses sought to identify participant characteristics that contributed to variability in gaze during an interactive context, only gaze data from low-low topics were analyzed in order to ensure that any associations found were not primarily driven by experimental manipulations related to topic demands, as this would limit the generalizability of any findings. FDR adjustments were used to correct for multiple comparisons.

6.4 EXPLORATORY FRAME-BY-FRAME ANALYSES

Given the exploratory nature of these analyses and the magnitude of possible comparisons between-groups for any given stimulus, a visual data mining approach advocated by Yu and colleagues (2012) for examining temporal patterns in gaze data was used to examine differences in the viewing proportions for the two groups (see also, Falck-Ytter, von Hofsten, Gillberg, & Fernell, 2013). According to this approach, raw viewing proportions were first inspected visually by creating graphs based on the continuous data, and then, specific moments of interest within the data stream (i.e., critical periods) were systematically identified for further analysis using a bottom-up, data driven approach (Yu, Yurovsky, & Xu, 2012). Specifically, *critical periods* were defined as times when the viewing proportion between-groups differed by at least .2 for a minimum of three consecutive time intervals or bins (i.e., a 999 ms interval of time). Although critical time periods had to include a minimum of three bins, the end of a critical period was determined by identifying the last bin in which viewing proportions differed between groups by at least .2.

Finally, Mann-Whitney *U* tests were conducted to identify *significant critical periods*, and qualitative trends associated with these periods were described. Given the exploratory nature of these analyses, Holm-Bonferroni adjustments, which are more conservative than FDR adjustments, were used to correct for multiple comparisons. In addition, frame-by-frame analyses were only conducted for a randomly selected subset of the available stimuli in order to further reduce the number of comparisons examined. Specifically, two out of the three stimuli for each topic condition were randomly selected, yielding a total of eight stimuli for these analyses.

7.0 RESULTS

7.1 PRELIMINARY ANALYSES

7.1.1 Post-Interaction Questionnaire ratings

Results from a series of Mann-Whitney *U* tests indicated that the autism group did not differ from the control group on ratings of suspicion, mean confederate responsiveness, or mean confederate likability (see Table 4). On average, participants in both groups reported that they felt neutral on the item assessing suspicion, indicating that they did not feel strongly that the interaction was atypical or typical (Control: M=3.47; Autism: M=2.95). Within the control group, three participants reported *somewhat* disagreeing with the suspicion check statement, whereas, within the autism group, one participant reported *strongly* disagreeing and eight participants reported *somewhat* disagreeing with it. After participants completed the Post-Interaction Questionnaire and prior to debriefing, the experimenter asked all participants who endorsed *somewhat* or *strongly* disagreeing with the suspicion check to explain what they thought was unusual about the interaction. Among these participants, one participant in the autism group stated he was "not entirely sure," that he was "talking to a real person." In addition, one participant in the control group reported being suspicious about the interaction being live, but only after debriefing occurred. However, the remaining participants identified various aspects of the interaction's structure as contributing to its atypicality (e.g., not using their partner's name and not being able to respond to what their partner said; see Appendix C for a list of the reasons provided). On average, participants from both groups rated the confederate as being responsive during the interaction, with the mean rating per question being 3.64 for participants in the autism group and 3.74 for participants in the control group. In contrast, participants reported feeling more neutral about the confederate's likability, with the average rating per question being 3.38 for participants in the autism group and 3.08 for participants in the control group.

Table 4. Means and Statistical Significance of Between-Group Differences for Post-Interaction Questionnaire Ratings

Post-Interaction Questionnaire Rating	**Group**	***M***	***SD***	***U***	***p***
Suspicion Check	Control (*n*=19)	3	1	126.50	.116
	Autism (*n*=19)	3	1		
Mean Confederate Responsiveness	Control (*n*=19)	3.74	0.46	140.00	.510
	Autism (*n*=17)	3.65	0.65		
Mean Confederate Likability	Control (*n*=19)	3.08	2.74	206.50	.284
	Autism (*n*=18)	3.38	3.36		

Note. Two participants in the autism group did not answer every question related to the confederate's responsiveness and likability, and thus, were not included in these analyses.

In addition to examining between-group differences on the Post-Interaction Questionnaire, ratings for participants who had previously used video-mediated communication (*n*=18) were compared to those of participants who had not (*n*=18), as it was possible that individuals familiar with video chatting would be more skeptical or critical of the interaction. Results from Mann-Whitney *U* tests indicated that these two groups did not differ in regard to their ratings of suspicion (*U*=-0.13, *p*=.895), mean confederate responsiveness (*U*=-0.10, *p*=.924), or confederate likability (*U*=-1.83, *p*=.067). Thus, participants' perceptions of the interaction and the confederate were similar, regardless of their prior experience using video-mediate communication.

Despite the null effects regarding Post-Interaction Questionnaire ratings and both group membership and video chatting experience, Pearson correlations were examined between ratings on the Post-Interaction Questionnaire and several indexes of visual attention to assess whether differences in participants' perceptions of the interaction still could have influenced patterns of visual attention. Specifically, relationships between suspicion check, responsivity, and likability ratings were examined for the percentage of time spent fixating the confederate's face, the mean fixation duration to the confederate's face, and the mean scanpath distance when either listening or responding to topics with low cognitive and low social demands. Results from these analyses yielded no significant associations between Post-Interaction Questionnaire ratings and any measure of visual attention (*p*s>.05, see Appendix D for correlation coefficients and their significance). Furthermore, all correlation coefficients were in or below the small effect range. Thus, variability in participants' ratings of the interaction and the confederate were not associated with differences in visual attention during the experimental task.

7.1.2 Viewing duration during the “Get Acquainted” exercise

Viewing durations of stimuli were examined as an additional way of assessing whether groups difference in experience during the “Get Acquainted” exercise.

7.1.2.1 Screening phase

During the screening phase, viewing duration was determined by the duration of time taken by participants to indicate whether the confederate’s face was familiar. Results from an independent samples *t* test indicated that both groups viewed the confederate’s face for a similar amount of time during the screening phase, with participants in the control group viewing the confederate’s image for 5.70 seconds (*SD*=3.46) and participants in the autism group viewing it for 5.21 seconds (*SD*=2.81), $t(36)=.474$, $p=.638$.

7.1.2.2 Interaction phase

During the interaction phase, viewing durations of stimuli were determined by the duration of responses to topics. However, because viewing durations during the listening condition were determined by the length of the confederate’s pre-recorded responses, and therefore standard across all participants, between-group differences were only analyzed during the responding condition. A MANOVA was conducted with group as a between-subjects variable and viewing durations for each of the 13 topics as the dependent variables. Even though Topic 1 was treated as a practice topic and excluded from the primary analyses, it was examined here to determine whether groups differed in their initial approach to the task. A summary of these analyses, including the means, standard deviations, and ranges for both groups, are shown in Table 5. No significant differences were found after adjusting for multiple comparisons, indicating that the autism group's responses were similar in length to those of the control group. Thus, during the responding condition, viewing durations did not differ between groups.

Table 5. Between-Group Differences in Viewing Durations (Seconds) during the Responding Condition

	Control Group		Autism Group			
Topic	*M(SD)*	Range	*M(SD)*	Range	*F*(1,36)	*p*[a]
1.	23.38 (11.9)	11.68 – 44.84	31.24 (11.05)	12.81 – 44.95	4.44	.273
2.	22.86 (8.44)	10.73 – 44.12	31.76 (12.18)	15.16 – 48.95	6.86	.169
3.	24.22 (8.75)	12.94 – 43.26	26.86 (8.38)	15.06 – 43.65	0.90	.826
4.	23.21 (7.90)	12.71 – 39.36	26.87 (10.58)	9.73 – 49.22	1.46	.826
5.	29.85 (8.16)	17.74 – 46.64	31.51 (13.52)	1.07 – 48.59	0.21	.826
6.	26.51 (9.40)	11.28 – 49.52	28.46 (9.92)	8.70 – 45.69	0.39	.826
7.	28.37 (8.78)	15.99 – 46.24	30.11 (11.95)	2.37 – 47.89	0.26	.826
8.	27.18 (9.06)	9.93 - 47.50	28.42 (10.51)	9.88 – 49.85	0.15	.826
9.	30.45 (8.31)	13.91 – 40.76	28.93 (9.85)	15.09 – 49.45	0.30	.826
10.	27.77 (7.61)	15.14 – 40.54	29.11 (9.55)	16.39 – 43.39	0.23	.826
11.	30.28 (7.78)	17.29 -44.85	28.45 (8.89)	12.89 – 44.55	0.45	.826
12.	30.66 (8.12)	18.41 – 43.16	31.25 (12.25)	1.55 – 45.39	0.03	.862
13.	25.55 (8.40)	13.66 – 42.66	24.99 (8.82)	10.84 – 39.18	0.04	.862

Note. [a]*p* values adjusted for multiple comparisons using a FDR correction.

Finally, the total number of responses that exceeded 40 seconds (the time in which a warning beep occurred, informing participants the time limit was almost up) were compared for the two groups using a chi-square test. Results from this analysis indicated that among participants in the autism group, there was a significantly greater number of responses in which the viewing duration exceeded 40 seconds (*n*=56) compared to the control group (*n*=24), X^2=12.80, *p*<.001.

7.1.3 Overall visual attention during the "Get Acquainted" exercise

Overall visual attention was assessed by the total duration of fixations to the Screen AOI, as well as to the Face AOI to clarify whether participants spent a similar amount of time looking at the screen, and more importantly, attending to the confederate's face. However, for the interaction phase, the total fixation duration during the interaction was converted to the mean total fixation duration by summing the total fixation durations across stimuli and dividing by the number of stimuli.

7.1.3.1 Screening phase

A pair of independent *t* tests examined the effect of group on the total duration of fixations to the Screen AOI and to the Face AOI when viewing the screening phase stimulus depicting the confederate. No significant differences in overall visual attention existed between the two groups for either the Screen AOI, *t*(36)=.93, *p*=.358, or the Face AOI, *t*(36)=.90, *p*=.375. Thus, participants in the autism group did not differ from the control group in the amount of time spent fixating the screen (*M*=4.33 vs. *M*=5.15 seconds, respectively) or the confederate's face (*M*=4.01 vs. *M*=4.56 seconds, respectively).

7.1.3.2 Interaction phase

Two, parallel mixed design ANOVAs with group (control, autism) as a between-subjects variable and with participant's role (listening, responding) as a within-subjects variable were conducted to determine whether differences existed in the mean total fixation duration to the screen or to the confederate's face. For the Screen AOI, there was a main effect of group, $F(1,36)=5.10$, $p=.030$, indicating that on average, participants in the autism group spent significantly less time looking at the screen than those in the control group (13.16 vs. 16.55 seconds). There was also a significant main effect of participant's role, $F(1,36)=182.89$, $p<.001$, with all participants looking longer at the screen when they were listening to the confederate's responses compared to when they were responding (19.55 vs. 10.15 seconds). However, the interaction between-group and participant's role was not significant, $F(1, 36)=.29$, $p=.594$. Thus, although the autism group looked less at the screen overall, both groups demonstrated a similar pattern of visual attention to stimuli depending on their role during the interaction (see Figure 4a).

In contrast, for the Face AOI, significant effects were found for group, $F(1,36)=6.40$, $p=.016$; participant's role, $F(1, 36)=258.56$, $p<.001$; and the Group X Participant's Role interaction, $F(1, 36)=7.52$, $p=.009$. As with fixations to the screen, participants in both groups spent less time fixating the confederate's face when responding to topics compared to when listening to the confederate's responses. However, post-hoc analyses examining the Group X Participant's Role interaction indicated that between-group differences in mean total fixation durations remained significant for stimuli in the listening condition, $F(1,36)=10.59$, $p=.004$, but not for stimuli in the responding condition, $F(1,36)=1.12$, $p=.296$. As shown in Figure 4b, participants in the autism group looked significantly less at the confederate's face when he was responding (i.e., during the listening condition) compared to participants in the control group. However, during the responding condition, participants in the two groups exhibited similar overall visual attention to the confederate's face.

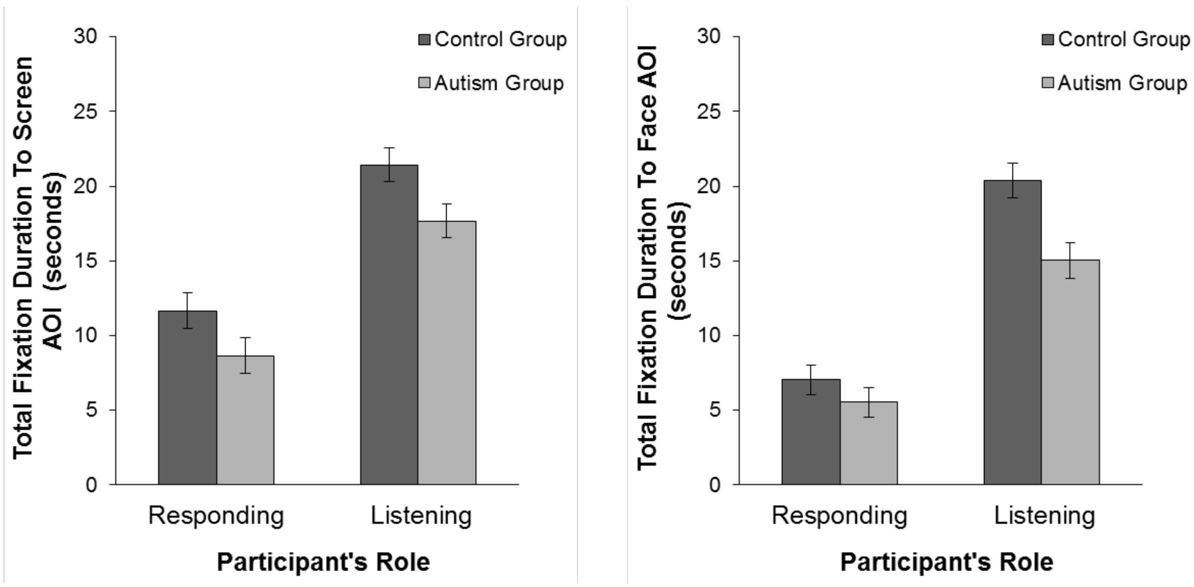

Figure 4. Mean total fixation duration (seconds) to the Screen AOI (a) and to the Face AOI (b) depending on group and participant's role. Error bars represent standard errors.

7.1.4 Ratings of eye contact importance and skill

Results from Mann-Whitney *U* tests revealed significant differences between groups on their ratings for the importance of eye contact (*U*=108.00, *n*=37, *p*=.042) and self-reported ratings of skill (*U*=103.50, *n*=37, *p*=.025). Specifically, participants in the control group rated eye contact as more important (*M*=4.37) and their ability to make eye contact as more skilled (M=3.84) compared to participants in the autism group (*M*=3.67 and *M*=3.06, respectively). Still, it is important to note that on average, participants in the autism group reported that making eye contact during interactions is generally important.

7.1.5 Summary and discussion of results from preliminary analyses

Because of the novel methodology employed in the current study, preliminary analyses were first conducted to determine whether the experimental task was successful in simulating a live, albeit structured, interaction using video-mediated communication, as this could have affected how participants attended to the confederate's face. For example, if participants suspected the interaction was fake, they make have looked at the confederate's face in an atypical way. Specifically, the effectiveness of the experimental paradigm in simulating a live interaction was assessed by examining participant ratings regarding the typicality of the interaction and the responsiveness and likeability of their partner. Results from these analyses indicated that the deception employed during the interaction was largely successful, even when prior experience with video chatting was examined. In general, participants in both groups rated the interaction as typical (i.e., not unusual), with the exception of it taking place within a lab setting. Furthermore, among participants who indicated the interaction was unusual, only one participant in each group indicated that they thought the interaction may have been faked.

In addition, participants on average rated the confederate positively in terms of his responsiveness, which suggests that the pre-recorded videos of the confederate were effective at giving the illusion of a partner who was listening attentively. Indeed, in terms of qualitative data, several participants expressed disbelief after being told that the interaction was not live, noting that their partner responded during the beginning task when the instructions were reviewed (e.g., waving when introduced). This suggests that the credibility cues were helpful in convincing participants that the interaction was live. With regard to the confederate's likability, participants on average endorsed neutral ratings. Although the confederate was in part selected for his friendly demeanor and thus, ratings of likability were expected to be more positive, this finding is not all that surprising given the short and structured nature of the interaction. Still, it was more important that the ratings of likability were not negative, as this could have influenced participants' effort, as well as their gaze patterns during the task (Kleinke, 1986). More important, results from these analyses suggest that participants' subjective experiences of the simulated interaction were similar for the two groups.

Even though these preliminary results indicate that at the group level, the deception was successful, it was still possible that individual differences in participants' perceptions were associated with differences in visual attention during the interaction. Thus, as an additional precaution, correlations between participant ratings and several indexes of visual attention were examined; however, no significant associations were found. Together, these results provide strong support regarding the ecological validity of the current study, suggesting that the patterns of visual attention observed are not an artifact of the simulated nature of interaction and thus, at a minimum can be extended to other structured interactions using video chatting.

In addition to assessing the effectiveness of the experimental procedure, preliminary analyses were conducted to examine whether participants' objective experiences of the "Get Acquainted" task were similar for the two groups. Specifically, it was important to assess whether both groups had a similar opportunity to view stimuli during the responding condition, as well as, whether both groups spent a similar amount of time attending to the stimuli. With regard to the screening phase of the task, results indicate that participants in the two groups did not differ regarding the duration of time they were able to view the confederate's face, the overall duration of time they spent fixating the screen, or the overall duration of time they spent fixating the confederate's face.

During the interaction phase, viewing durations for stimuli were also similar for the two groups during the responding condition. Furthermore, the average duration of the *confederate's responses* (i.e., the listening condition stimuli) did not differ from the average duration of *participants' responses* for either the control group or the autism group, indicating that amount of time in which stimuli could be viewed was similar across listening and responding conditions. However, differences in overall visual attention to stimuli were found during the interaction phase. Specifically, participants in the autism group spent less time compared to those in the control group fixating the entire stimuli (i.e., Screen AOI), as well as less time fixating the confederate's face, particularly during the listening condition. Furthermore, both groups demonstrated shorter total fixation durations to stimuli when responding compared to listening.

Although these results indicate that differences existed among participants in terms of their overall attention during the interaction phase of the experiment, these differences are thought to meaningful, reflecting true differences in visual attention depending on a participant's diagnosis and role, rather than some confounding factor, such as the amount of effort put forth by participants during the experiment. For example, if these differences were confounded by an ulterior variable such as effort, similar, if not greater differences should have also been found for the duration of participants' responses, as participants have greater control over this overt behavior.

However, as reviewed above, differences in response durations did not exist between groups or between participant's role conditions. Nevertheless, these results are important as autism researchers often use overall visual attention to the entire stimulus or to the facial region of a stimulus to normalize visual attention to facial features (e.g., Norbury et al., 2009), which could at times, lead to misleading findings. For example, this method of normalizing gaze data would make it possible for two participants to exhibit similar percentages of time fixating the eyes relative to the face, even though one participant spent twice as much time fixating the eyes. Although these differences in the interpretation of data are meaningful during face perception tasks, they are particularly significant when examining face processing during an interactive context, as in the current study.

7.2 EFFECTS OF STIMULUS TYPE ON VISUAL ATTENTION

Hypothesis 1 posited that between-group differences in patterns of visual attention would differ only when more complex stimuli were viewed relative to simpler stimuli. To examine this hypothesis, patterns of visual attention to facial features were compared for three stimulus types: static (i.e., the stimulus viewed when participants indicated whether the confederate was familiar during the screening phase), Dynamic-Listening (D-List; i.e., the dynamic audiovisual stimuli viewed when participants listened during the interaction), and Dynamic-Responding (D-Resp; the dynamic stimuli viewed without audio when participants responded during the interaction).

7.2.1 Percentage of time spent fixating AOIs

A mixed design ANOVA was run with group (control, autism) as a between-subjects variable, stimulus type (static, D-List, D-Resp) as a within-subjects variable, and %Eyes, %Nose, %Mouth, and %Face as dependent variables. As shown in Table 6, there was a main effect of group for %Nose and %Face, indicating that overall, the autism group spent a smaller percentage of time fixating the confederate's nose (*M*=9.53%) and face (*M*=50.83%) compared to the control group (*M*=17.35% and *M*=61.59%, respectively).

Table 6. Summary of Descriptive and Inferential Statistics for the Effects of Group and Stimulus Type on the Percentage of Time Spent Fixating AOIs

		STIM						ANOVA Results					
		Static		D-List		D-Resp		STIM		GRP		STIM X GRP	
AOI	GRP	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	Sig.	*F*	Sig.	*F*	Sig.
Eyes	CON	22.13	33.80	9.96	11.69	4.91	5.64	19.92	***	0.98	ns	2.18	ns
	AUT	35.91	27.46	8.20	7.15	4.70	7.74						
Nose	CON	29.46	29.21	15.73	10.64	6.86	5.98	15.03	***	5.94	*	1.16	ns
	AUT	16.44	16.24	8.45	9.69	3.70	5.49						
Mouth	CON	11.75	13.13	20.53	16.60	4.17	4.81	22.35	***	1.01	ns	0.64	ns
	AUT	9.28	11.46	15.22	12.41	3.55	4.75						
Face	CON	85.68	12.97	72.96	12.63	26.12	14.11	163.67	***	6.83	**	3.55	*
	AUT	80.43	17.89	51.87	24.83	20.19	19.01						

Note. STIM=Stimulus Type; GRP=Group; CON=Control Group; AUT=Autism Group; D-List=Dynamic Listening Stimulus; D-Resp=Dynamic Responding Stimulus; Sig.=Significance.
**p*<.05. ***p*<.01. ****p*<.001.

In addition, for all dependent variables, there was a significant main effect of stimulus type (*p*s<.01). Post-hoc, independent samples *t* tests were conducted to examine how the percentage of time spent fixating differed between each pair of stimuli. Results from these analyses are summarized in Table 7. As can be seen, significant differences were found for each possible contrast and for all AOIs, even after adjusting significance values for multiple comparisons.

Table 7. Significance of Post-Hoc Contrasts for Main Effect of Stimulus Type on the Percentage of Time Spent Fixating AOIs

	Static vs. D-List		Static vs. D-Resp		D-Resp vs. D- List	
	t(37)	Sig.	*t*(37)	Sig.	*t*(37)	Sig.
Eyes	4.14	***	4.72	***	2.75	*
Nose	2.81	**	4.53	***	5.23	***
Mouth	-3.14	**	3.50	**	7.03	***
Face	5.32	***	16.26	***	14.19	***

Note. D-List=Dynamic-Listening Stimulus; D-Resp=Dynamic-Responding Stimulus; Sig.=Significance.

*p<.05. **p<.01. ***p<.001.

As shown in Figure 5, participants fixated for a significantly greater percentage of time on the eyes, nose, and face when viewing a static image of the confederate's face compared to stimulus conditions when participants either listened to a dynamic stimulus or responded while looking at a dynamic stimulus (*p*s<.01). For each of these AOIs, the percentage of time participants spent fixating was also significantly greater for D-List stimuli compared to D-Resp stimuli (*p*s<.05). However, participants demonstrated a somewhat different pattern when viewing the confederate's mouth. Although participants fixated the mouth region for a greater percentage of time during the static stimulus condition compared to D-Resp condition, participants spent the greatest percentage of time fixating the confederate's mouth during the listening portions of the interaction.

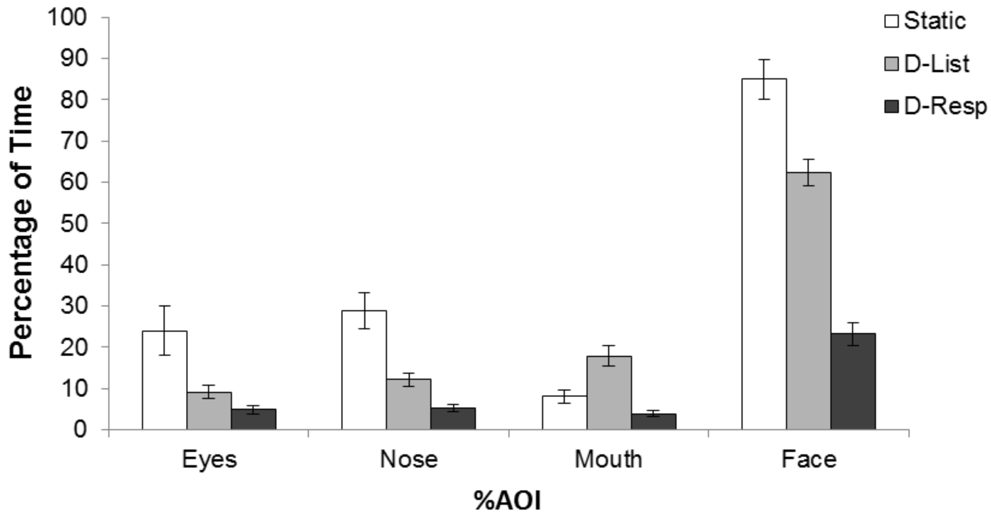

Figure 5. Effect of stimulus type on the percentage of time spent fixating areas of the confederate's face. Error bars represent standard errors.

Finally, for %Face, there was a significant Group X Stimulus Type interaction. As shown in Figure 6, post-hoc comparisons indicated that participants in the autism group spent a significantly smaller percentage of time fixating the confederate's face when viewing a dynamic, audiovisual stimuli during the D-List condition compared to participants in the control group, $t(26.73)=3.30$, $p=.008$. In contrast, the two groups did not differ in the percentage of time they spent fixating the confederate's face when viewing a static stimulus, with the control group looking 85.68% of the time and the autism group looking 80.43% of the time, $t(36)=1.04$, $p=.307$. Likewise, differences between groups in %Face were not significant for the D-Resp condition, indicating that participants in the autism and control groups fixated the confederate's face for a similar percentage of time while responding during the interaction, $t(36)=1.09$, $p=.307$.

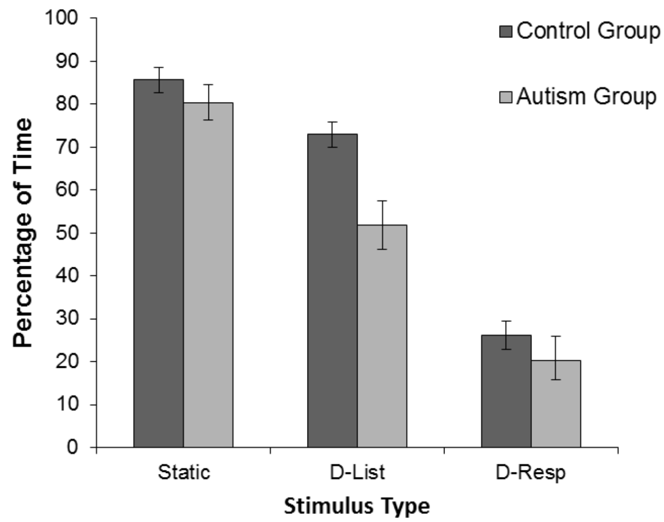

Figure 6. Percentage of time each group spent fixating the confederate's face depending on the type of stimulus viewed. Error bars represent standard errors.

Although fixation durations for the static and dynamic stimuli were standardized by viewing durations when calculating the percentage of time spent fixating AOIs, it is worth considering the possibility that patterns of visual attention could change over prolonged exposure to a stimulus. If so, the adjustments made to standardize visual attention across the three stimulus types may have been inadequate, as the static stimulus was viewed for a much shorter duration (M=5.46 seconds) than either type of dynamic stimulus (D-List: M=26.72 seconds; D-Resp: M=28.01 seconds). As a result, the percentage of time spent fixating AOIs was recalculated using only the first 5.46 seconds of fixation data for dynamic stimuli, and the omnibus ANOVA was rerun. However, the resulting pattern of significant effects from this revised analysis mirrored that obtained in the initial analysis, and the group means for both types of dynamic stimuli were remarkably similar between the original and revised analyses. As a result, findings from this revised analysis are not reported here, though adjusted means, standard deviations, and test statistics for this revised analysis are summarized in Appendix E. Thus, the reported differences in patterns of visual attention among stimulus types do not appear to be an artifact of between-condition differences in viewing durations.

7.2.2 Mean fixation duration

A mixed design ANOVA was conducted to examine the effects of group, a between-subjects variable, and stimulus type, a within-subjects variable, on the average duration of fixations to the confederate's face. There was a main effect of stimulus type, $F(1,36)=9.18$, $p=.001$. Post-hoc comparisons indicated that participants exhibited shorter fixations when viewing D-Resp stimuli (i.e., when they were responding during the interaction; $M=333$ ms) compared to when viewing a static stimulus of the confederate ($M=554$ ms), $t(37)=2.81$, $p=.012$. The mean fixation duration to the confederate's face when responding was also shorter to that when listening during the interaction ($M=652$ ms), $t(37)=5.94$, $p<.001$. In contrast, participants' mean fixation durations were not significantly different when viewing a static image of the confederate compared to when viewing D-List stimuli, $t(37)=1.07$, $p=.293$.

Interestingly, neither the main effect of group, $F(1,36)=2.94$, $p=.100$, nor the interaction effect between group and stimulus type was significant, $F(2, 56.99)=.97$, $p=.368$. Finally, an independent *t* test was conducted to examine the planned contrast that predicted that the autism group would demonstrate longer mean fixation durations compared to control group during the dynamic-listening condition. Contrary to this prediction, participants in the control group exhibited longer fixation durations on average (*M*=756 ms) compared to those in the autism group (*M*=548 ms); however, consistent with the omnibus analysis, this difference between-groups was not significant, *t*(36)=1.55, *p*=.130.

7.2.3 Summary and discussion of results

A primary aim of the current study was to compare patterns of visual attention when viewing a static stimulus to that when viewing more ecologically-valid stimuli, as the bulk of autism research on visual attention to faces has used static stimuli and it is unclear to what extent these finding can be generalized to how individuals with ASD attend to dynamic faces in interactive contexts. To address this aim, the percentage of time spent fixating AOIs and the mean fixation duration were examined when participants viewed three different types of face stimuli across a single identity: static, D-List, and D-Resp. Because this study is the first to directly compare visual attention when viewing static stimuli to that when viewing dynamic stimuli within an interactive context, overall patterns are discussed first, followed by a discussion of between-group differences.

First, across all facial regions (eyes, nose, mouth, and face), significant differences in the proportion of time individuals spent fixating were found for each contrast between stimulus conditions. Thus, each type of stimulus had a unique effect on how individuals distributed their attention to regions of the confederate's face. Interestingly, for all regions except for the mouth, a similar pattern was observed across stimulus conditions, such that individuals spent the greatest amount of time, relative to how long the stimulus was viewed, fixating AOIs in the static condition, followed by the D-List condition, and then the D-Resp condition. In contrast, individuals spent the greatest amount of time fixating the mouth during the D-List condition.

Still, consistent with the other facial regions, the percentage of time spent fixating the mouth was smallest during the D-Resp condition. Furthermore, these patterns of visual attention did not change when viewing durations were held constant across stimulus types by analyzing only a portion of the data collected for each dynamic stimulus (i.e., approximately the first 5 seconds in which a stimulus was presented), indicating that the observed differences in gaze did not result from differences in the length of time in which stimuli were able to be viewed.

In addition, results from these analyses indicate that the mean duration of fixations also vary depending on the type of stimulus viewed, though distinct patterns were not found for all stimulus types. Specifically, fixations were the longest during the D-List condition (652 ms), followed by the static condition (554 ms), and then the D-Resp condition (333 ms), though differences between the static and D-List conditions did not reach statistical significance. Given that longer fixation durations are thought to indicate less efficient processing or a compensatory strategy during complex tasks (so that visual information is not missed during saccades), neither of these explanations clarify why mean fixation durations for a static stimulus were similar in length to those for a dynamic, audiovisual stimulus (i.e., D-List condition) and were longer than those for a silent, dynamic stimulus (i.e., D-Resp condition). Thus, it may be these associations are only applicable when examining mean fixation durations within a specific type of stimuli (e.g., comparing two types of static stimuli) or when stimuli are passively viewed, and thus one does not need to consider how prolonged fixations may be perceived socially. Nevertheless, these findings indicate that the type of stimulus used has a robust effect on patterns of visual attention, particularly with regard to how individuals distribute their attention to facial regions. As a result, these findings provide additional evidence that visual attention to static faces differs from that when viewing more realistic, dynamic faces, thereby highlighting the importance of research using more ecologically-valid stimuli in order to understand how individuals with and without ASD process faces in naturalistic settings.

With regard to between-group differences in visual attention, Hypothesis 1 predicted that differences in visual attention would be found between the control group and the autism group when viewing dynamic stimuli, but not when viewing a static stimulus. More specifically, it was predicted that the autism group would fixate on the confederate's face for a smaller percentage of time and exhibit longer mean fixation durations when viewing stimuli during the dynamic-listening condition. However, results from these analyses provide only partial support for Hypothesis 1. As predicted, participants in the autism group fixated the confederate's face for significantly less time when viewing dynamic stimuli during the listening portions of the interaction (~50% of the time) compared to participants in the control group (~73% of the time), whereas the two groups did not differ in the percentage of time spent fixating the confederate's face during the static condition. However, no differences were found between groups related to the mean duration of fixations, even when mean fixation durations were specifically examined for the D-List condition.

In addition to the predicted effects of stimulus type on visual attention, these analyses yielded two unexpected results concerning group differences, or a lack thereof. First, regardless of stimulus type, participants in the control group spent a greater portion of time looking at the confederate's nose compared to those in the autism group. Although fixations to the nose region were predicted to be influenced by a topic's cognitive demands, no specific predictions were made concerning between-group differences in visual attention to the nose, particularly for these analyses since gaze data were only analyzed for topics with low cognitive and low social demands. The fact that the percentage of time spent fixating the nose differentiated the two groups, even during the static condition, suggests that this may represent a primary difference in how individuals with ASD process facial information, as this effect was independent of both stimulus type and task demands. Though unexpected, this finding is significant as the bulk of autism research on face processing has focused on differences in visual attention to the eye region relative to the mouth region (e.g., Klin et al., 2002; Norbury et al., 2009; Speer et al., 2007), with fixations to the nose region either excluded from analyses (e.g., Falck-Ytter et al., 2010; Fletcher-Watson et al., 2009) or lumped together with the eye region (e.g., Bal et al., 2010); Jones et al., 2008) or some other face region (e.g., Anderson et al., 2006). Among studies that did not report gaze data for the nose region, it is not clear whether visual attention to the nose region was examined but not reported because between-group differences in gaze were not significant (i.e., the file drawer problem) or whether potential, between-group differences in gaze to the nose region were ignored. Likewise, it is possible that some of the reported, between-group differences in visual attention to the eyes may actually reflect differences in gaze to the nose. Thus, these results highlight the need for greater specificity when identifying differences in face-directed gaze among individuals with ASD, as well as greater transparency in terms of how AOIs are defined, as a number of studies do not report this information (e.g., Norbury et al., 2009; Speer et al., 2007).

In addition, it is important to note that patterns of visual attention to dynamic, face stimuli were remarkably similar between groups during the D-Resp condition, with the exception of the nose region, which as indicated above was not unique to this condition. For example, results indicate that TD adults spent 26% of the time fixating the confederate's face while responding to low-low topics, whereas, adults with ASD spent 20% of the time fixating the confederate's face. Although no specific predictions were made for the D-Resp condition, it was expected that stimuli viewed during this condition would be more visually demanding to process relative to the stimulus viewed during the static condition, and thus, more likely to result in atypical patterns of visual attention among individuals with ASD. One possible explanation for this null effect is that the percentage of time individuals in both groups spent fixating the confederate's face was greatly reduced during the D-Resp condition and thus, resulted in a floor effect. Visual inspection of the mean percentages of time individuals in each group spent fixating facial features during the D-Resp condition provides some support for this possibility, with the autism group fixating the confederate's eyes, nose, and mouth for a smaller percentage of time compared to the control group. Still, these differences between groups were small, ranging from 3.16 % to 0.21% depending on the facial feature. Given the restricted data range in this condition, analysis of individual differences in the autism group may help clarify whether this finding accurately represents how individuals with ASD attend to a communicative partner's face when speaking.

7.3 EFFECTS OF PARTICIPANT'S ROLE AND TOPIC DEMANDS ON VISUAL ATTENTION

7.3.1 Percentage of time spent fixating AOIs

A mixed design 2 (Group) x 2 (Participant's Role) x 2 (Cognitive Demands) x 2 (Social Demands) ANOVA was run with %Eyes, %Nose, %Mouth, and %Face as dependent variables. A comprehensive summary of the results from these analyses is shown in Table 8 (see Appendix

F for means and standard deviations for the percentage of time spent fixating AOIs by group, participant's role, and topic demands).

Table 8. Results from 2(Group) X 2(Participant's Role) X 2(Cognitive Demands) X 2(Social Demands) ANOVAs for the Percentage of Time Spent Fixating the Eyes, Nose, Mouth, and Face

	Eyes	Nose	Mouth	Face
Effect	*F*(1,36)	*F*(1,36)	*F*(1,36)	*F*(1,36)
Grp	0.28	6.47*	0.03	6.15*
PR	8.81**	38.93***	56.21***	278.29***
Cog	0.18	2.81	0.27	0.32
Soc	0.13	0.02	2.04	2.06
Grp * PR	0.90	3.78	0.01	7.80**
Grp * Cog	0.48	0.22	1.68	0.02
Grp * Soc	2.67	0.30	3.25	0.91
PR * Cog	0.23	9.32**	2.95	1.63
PR * Soc	1.10	13.50**	1.43	$3.86^{\dagger}$
Cog * Soc	0.21	1.10	2.13	8.69**
Grp * PR * Cog	0.02	$3.59^{\dagger}$	1.57	1.45
Grp * PR * Soc	2.82	2.25	$3.96^{\dagger}$	0.02
Grp * Cog * Soc	0.11	0.13	1.58	0.65
PR * Cog * Soc	0.33	3.33	0.00	0.11
Grp * PR * Cog * Soc	0.02	1.62	0.90	1.41

Note. Grp=Group; PR=Participant's Role; Cog=Cognitive Demands; Soc=Social Demands.

*$p<.05$. **$p<.01$. ***$p<.001$.

As shown in Table 8, there was a main effect of participant's role for all dependent variables (*p*s<.01). Participants in both groups spent a significantly greater portion of time fixating the confederate's facial features and face when listening compared to responding (see Figure 7). For example, during the listening condition, fixations to the confederate's face accounted for nearly 65% of the viewing duration, whereas, in the responding condition, they accounted for approximately 24% of the viewing duration. It is also important to note that although relative decreases in the percentage of time spent fixating AOIs were found for all facial features when responding compared to listening, the magnitude of this decrease, as indicated by difference scores, differed among features. Participants demonstrated the greatest reduction in the percentage of time spent fixating the mouth region (14.15%), followed by the nose region (8.20%), and then the eye region (5.41%). This suggests that gaze to the eyes was the most stable during the interaction and that gaze to the mouth was the most variable.

Despite the similar effects of participant's role on gaze across AOIs, the effects of group and topic demands (cognitive and social), as well as the interaction effects among variables differed depending on the AOI examined. Thus, the remaining results are first discussed for the eyes and mouth, as these regions yielded a similar pattern of effects. Afterward, the remaining results for the nose region are discussed, followed by those for the face region, and then culminating with those for specific planned contrasts.

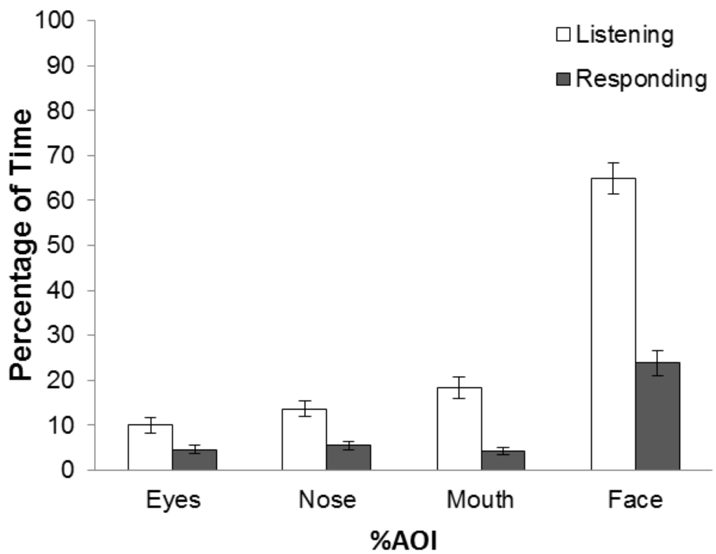

Figure 7. Percentage of time spent fixating AOIs depending on participant's role. Error bars represent standard errors.

With regard to %Eyes and %Mouth, results indicated that the percentage of time participants spent fixating these regions of the confederate's face were relatively stable both between groups and across topic conditions, regardless of their associated cognitive and social demands. Indeed, no significant main effects or interaction effects were found for either of these regions, with the exception of the effects of participant's role already noted above (see Table 8). For instance, results indicated that participants in the control group spent 7.91% of the time fixating the confederate's eyes and 11.59% of the time fixating his mouth during the interaction, whereas, participants in the autism group fixated these regions 6.74% and 11.08% of the time, respectively. Likewise, neither the %Eyes nor the %Mouth differed when a topic's cognitive demands were low compared to high (%Eyes: *M*=7.32% vs. 7.33%; %Mouth: *M*=11.23% vs. 11.24%) or when a topic's social demands were low compared to high (%Eyes: *M*=7.17% vs. 7.48%; %Mouth: *M*=11.64% vs. 11.03%). Thus, although the duration of gaze to the confederate's eyes and mouth, as assessed by the percentage of time spent fixating these regions, was influenced by participant's role during the interaction, the duration of gaze to these regions was independent of both group membership and topic demands.

For %Nose, there was a significant main effect of group (p=.015), indicating that across the "Get Acquainted" exercise, participants in the control group spent a greater proportion of time fixating the confederate's nose than those in the autism group. On average, participants in the control group spent 13.66% of the time that a stimulus was visible looking at the confederate's nose, whereas participants in the autism group only spent 5.46% of the time that a stimulus was visible looking at the confederate's nose. In addition, there were 2 significant two-way interactions, one between participant's role and cognitive demands (p=.004) and one between participant's role and social demands (p=.001).

As shown in Figure 8, post-hoc analyses for the Participant's Role X Cognitive Demands interaction indicated that during the listening portions of the interaction, participants spent a greater percentage of time fixating the confederate's nose when topics had high cognitive demands (i.e., when the confederate was describing events from his childhood) compared to when topics had low cognitive demands (i.e., when the confederate was describing recent events), $t(37)=2.57$, p=.028. However, participants fixated the confederate's nose approximately 5% of the time when responding during the interaction, regardless of a topic's cognitive demands, $t(37)=0.75$, p=.418.

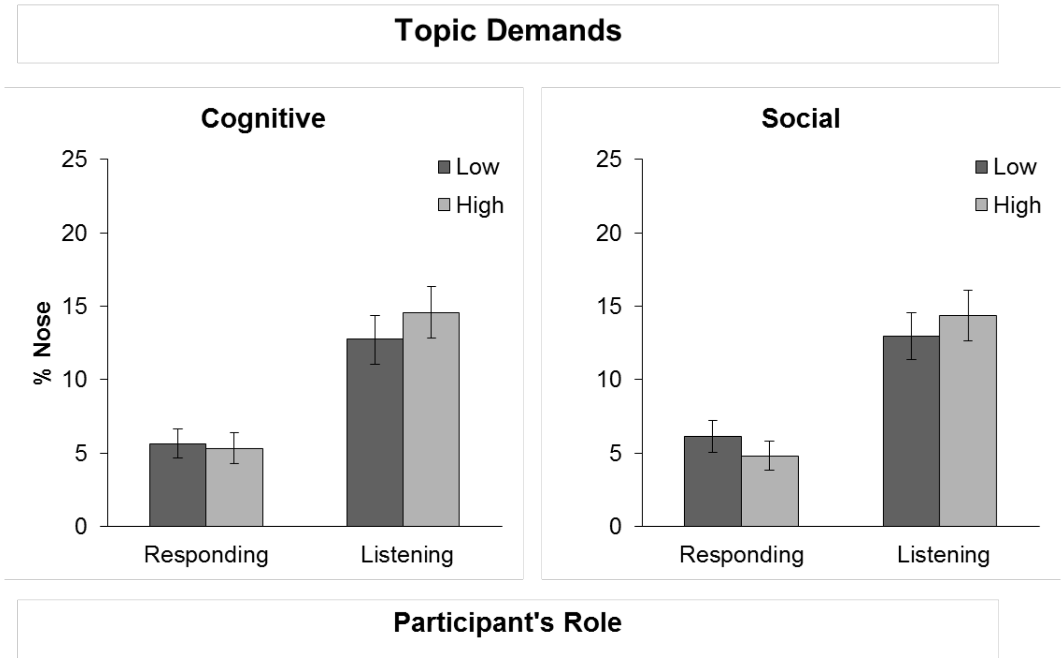

Figure 8. Percentage of time spent fixating the nose region depending on topic demands and participant's role. Error bars represent standard errors.

In contrast to the results related to a topic's cognitive demands, post-hoc analyses for the Participant's Role X Social Demands interaction indicated that participants spent a greater percentage of time looking at the confederate's nose when responding to topics that had low social demands (i.e., when sharing neutral or positive experiences) compared to when topics had high social demands (i.e., when sharing negative experiences), $t(37)=2.6$, $p=.014$. There was also a nonsignificant trend suggesting that participants may demonstrate the opposite pattern when listening, fixating the nose region for a greater percentage of time when the confederate responded to topics that had high social demands compared to low social demands, $t(37)=1.99$, $p=.054$. However, neither of these interactions differed depending on group, indicating that although the autism group fixated the nose for a smaller percentage of time compared to the control group, their gaze directed to the nose was similarly affected by both their role during the interaction and a topic's cognitive and social demands ($ps>.05$).

For %Face, there was a significant main effect of group ($p=.018$), a significant Group x Participant's Role interaction ($p=.008$), and a significant Cognitive Demands x Social Demands interaction ($p=.006$). Despite an overall trend indicating that participants in the control group fixated the confederate's face for a greater percentage of time than participants in the autism group, post-hoc analyses for the Group x Participant's Role interaction revealed that this effect was driven by differences in gaze during the listening portions of the interaction, $t(37)=3.27$, $p=.004$. As shown in Figure 9, participants in the control group spent a significantly greater portion of time fixating the confederate's face while he was speaking (M=74.82%) compared to participants in the autism group (M=55.06%), whereas both groups spent a similar percentage of time fixating the confederate's face while responding to topics during the interaction, $t(37)=1.10$, $p=.278$.

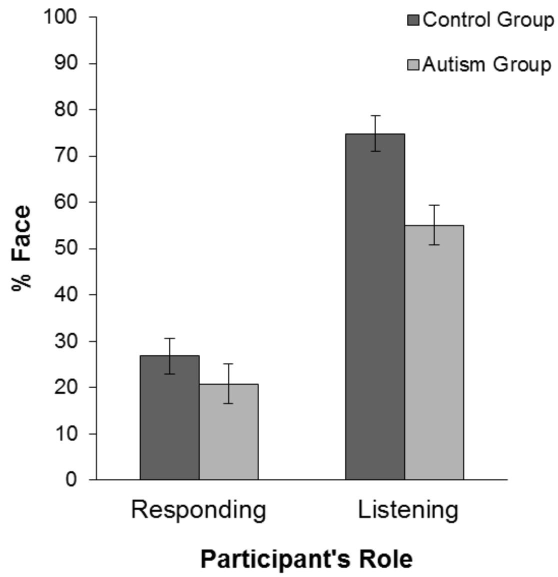

Figure 9. Percentage of time spent fixating the confederate's face depending on participant's role during the interaction. Error bars represent standard errors.

In addition, paired *t* tests were conducted to explore the Cognitive Demands x Social Demands interaction. Results from these analyses indicated that when *cognitive demands were low*, participants spent a greater percentage of time fixating the confederate's face when a topic's social demands were high (i.e., high social topics; *M*=46.35%) rather than low (i.e., low-low topics; *M*=42.79%), *t*(37)=2.25, *p*=.034). In contrast, *when cognitive demands were high*, participants demonstrated the reverse pattern, fixating for a greater percentage of time on the confederate's face when social demands were low (i.e., high cognitive topics; *M*=47.06%), compared to when they were high (i.e., high-high topics; *M*=41.30%), *t*(37)=3.05, *p*=.008. Thus, participants spent the greatest percentage of time fixating the confederate's face when topics had either high cognitive demands (e.g., "Tell about a time when you were a child, and you felt proud of yourself") or high social demands (e.g., "Describe a time when you were nervous or afraid in the last year"), but not both. On the other hand, participants spent relatively less time fixating the confederate's face when topics had either low cognitive and low social demands (e.g., "Share a time when you felt happy during the past week") or high cognitive and high social demands (e.g., "Share a time when you were a child and had your feelings hurt").

In addition to the results from the omnibus test, paired *t* tests were conducted to examine planned contrasts between the following experimental conditions: low-low topics compared to high social topics across participant's role conditions for the %Eyes (Contrast 4), low-low topics compared to high cognitive topics when participants were responding for the %Eyes (Contrast 5), and low-low topics compared to high cognitive topics when responding for the %Nose (Contrast 6). Consistent with results from the omnibus test, neither contrast examining differences in the %Eyes was significant (ps>.05), indicating that there was no difference in the percentage of time participants spent fixating the eye region during low-low topics relative to high social topics (M=6.95% vs. M=7.54%), nor was there a difference in the percentage of time participants spent fixating the eye region when responding to low-low topics relative to high cognitive topics (M=4.81% vs. M=4.77%).

For contrast 6, results from a paired *t* test indicated that participants spent a significantly greater percentage of time fixating the confederate's nose when responding to high cognitive topics (M=6.95%) compared to low-low topics (M=5.28%), $t(37)=2.02$, $p=.026$, one-tailed. However, a follow-up *t* test examining difference scores (which were based on differences in %Nose for these two conditions) indicated that the magnitude of this effect did not differ between groups, $t(37)=.72$, $p=.474$. On average, participants in the control group demonstrated a 2.26% increase in the amount of time spent fixating the confederate's nose when talking about positive experiences from childhood compared to more recent positive experiences, whereas participants in the autism group demonstrated 1.06% increase in the amount of time spent fixating the confederate's nose.

7.3.2 Mean fixation duration to the confederate's face

A mixed design ANOVA was conducted with group as a between-subjects variable, and with participant's role, cognitive demands, and social demands each as within-subjects variables to examine differences in the mean fixation durations during the interaction. As can be seen in Table 9, results of this analysis were largely non-significant (see Appendix G for means and standard deviations).

Table 9. Results from 2(Group) X 2(Participant's Role) X 2(Cognitive Demands) X 2(Social Demands) ANOVA on Mean Fixation Duration

Effect	*F*(1,36)	*p*
Grp	2.17	.149
PR	24.90	**<.001**
Cog	2.17	.149
Soc	2.51	.122
Grp * PR	3.21	.082
Grp * Cog	0.09	.764
Grp * Soc	0.39	.539
PR * Cog	0.57	.455
PR * Soc	0.65	.425
Cog * Soc	1.37	.249
Grp * PR * Cog	0.16	.687
Grp * PR * Soc	1.50	.228
Grp * Cog * Soc	0.94	.337
PR * Cog * Soc	0.46	.504
Grp * PR * Cog * Soc	1.98	.168

Note. Grp=Group; PR=Participant's Role; Cog=Cognitive Demands; Soc=Social Demands. Significant *p* values shown in bold.

Overall, the mean duration of fixations to the confederate's face did not differ significantly between groups (p=.149), with fixations lasting on average 581 ms for participants in the control group and 438 ms for participants in the autism group. Likewise, mean fixation durations were similar in length regardless of a topic's cognitive demands (Low: M=497 ms vs. High: M=523 ms; p=.149) or social demands (Low: M=525 ms vs. High: M=495 ms; p=.122). Furthermore, results indicated that there were no significant interactions among any of the independent variables (ps>.05). However, there was a significant main effect of participant's role (p<.001), such that participants exhibited longer fixations when they were listening (M=682 ms) compared to when they were responding during the interaction (M=338 ms).

Although this analysis did not yield any differences between groups, it was possible that these null findings resulted from the increased variability in mean fixation durations among participants in the control group (see Appendix G), which were particularly pronounced when participants listened to the confederate's responses to high cognitive topics. Inspection of the raw data revealed that this increased variability resulted from one participant in the control group who exhibited extremely long mean fixation durations (3.45 *SD* above the mean). As a result, this analysis was rerun excluding this participant (adjusted means and standard deviations for the control group are included in Appendix G). However, the pattern of significant effects from this revised analysis was identical to the pattern obtained in the initial analysis. Consistent with results from the initial analysis, only the effect of participant's role was significant, $F(1,35)=39.18$, $p<.001$, thus providing additional evidence that mean fixation durations did not differ depending on group or topic demands.

7.3.3 Mean scanpath distance

A mixed design ANOVA was conducted to examine the effects of group, participant's role, and topic demands (cognitive and social) on the mean scanpath distance. A comprehensive summary of all main effects and interactions among the independent variables for this analysis is shown in Table 10 (see Appendix H for means and standard deviations).

Table 10. Results from 2(Group) X 2(Participant's Role) X 2(Cognitive Demands) X 2(Social Demands) ANOVA for Mean Scanpath Distance

Effect	$F(1,36)$	p
Grp	2.98	.093
PR	66.41	**<.001**
Cog	0.12	.736
Soc	1.67	.204
Grp * PR	17.27	**<.001**
Grp * Cog	0.66	.421
Grp * Soc	0.51	.480
PR * Cog	0.07	.795
PR * Soc	24.45	**<.001**
Cog * Soc	0.94	.339
Grp * PR * Cog	0.31	.581
Grp * PR * Soc	4.44	**.042**
Grp * Cog * Soc	0.31	.583
PR * Cog * Soc	1.92	.174
Grp * PR * Cog * Soc	1.15	.290

Note. Grp=Group; PR=Participant's Role; Cog=Cognitive Demands; Soc=Social Demands.
Significant *p* values shown in bold.

Results indicated that there was a significant main effect of participant's role, $p<.001$. Overall, participants demonstrated longer scanpaths between fixations when they were responding (*M*=139.11 pixels) compared to when they were listening (*M*=100.51 pixels) during the interaction. The effect of group approached significance (*p*=.093), indicating that there was a nonsignificant trend for participants in the autism group to exhibit shorter scanpath distances (*M*=107.11 pixels) compared to participants in the control group (*M*=132.51 pixels). In contrast, neither a topic's social demands (*p*=.204) nor a topic's cognitive demands had a significant effect on the mean distance between fixations (*p*=.736). However, results revealed a significant Group x Participant's Role interaction (*p*<.001) and a significant Participant's Role x Social Demands interaction (*p*<.001). More important, there was a significant three-way interaction for group, participant's role, and social demands (*p*=.042).

To explore the Group x Participant's Role x Social Demands interaction, parallel 2 (Group) x 2 (Social Demands) mixed ANOVAs were conducted for the listening and the responding conditions. As shown in Table 11, there was a main effect of social demands for both these analyses. When responding, participants exhibited longer mean scanpath distances when topics had high social demands (*M*=144.17 pixels) compared to when topics had low social demands (*M*=134.06 pixels). However, participants demonstrated the reverse pattern during listening portions of the interaction, exhibiting longer mean scanpath distances when topics had low social demands (*M*=103.66 pixels) rather than high social demands (*M*=97.36 pixels).

Table 11. Effects of Group and Social Demands on Mean Scanpath Distance (Pixels) Depending on Participant's Role

	ANOVA Results					
	Group		Social Demands		Group X Social Demands	
Participant's Role	*F*(1,36)	Sig.	*F*(1,36)	Sig.	*F*(1,36)	Sig.
Listening	.18	ns	10.80	*	1.63	ns
Responding	6.90	*	16.60	***	3.36	ns

Note. Sig.=significance; ns= nonsignificant.

*p<.05. **p<.01. ***p<.001.

In addition, analysis of mean scanpath distances during the responding condition yielded a significant main effect of group, indicating that participants in the control group demonstrated longer distances between fixations when responding to topics (M=161.66 pixels) compared to participants in the autism group (M=116.57 pixels; p=.020). In contrast, the mean scanpath distance exhibited by the control group during listening portions of the interaction did differ from that exhibited by the autism group (M=103.36 pixels vs. M=97.66 pixels, respectively; p=.680).

Based on the planned contrasts outlined above, a paired t test was conducted to test the specific prediction that participants would demonstrate shorter mean scanpath distances when responding to high cognitive topics compared to low-low topics (Contrast 7). Results revealed a nonsignificant trend in the prediction direction, with the average distance between fixations being slightly smaller when participants talked about positive experiences from their childhood (M=130.24 pixels) compared to more recent positive experiences (M=137.89 pixels), $t(37)$=1.37, p=.090, one-tailed.

7.3.4 Summary and discussion of results: Effects of participant's role and topic demands on visual attention

A second aim of the current study was to characterize top-down changes in visual attention when viewing dynamic face stimuli during an interactive context and to explore whether these changes differed between individuals with and without ASD. As such, this study assessed the effects of group, conversational role, cognitive demands, and social demands during a simulated, video-mediated interaction on various aspects of gaze, including the percentage of time spent fixating different facial regions, the mean duration of fixations, and the mean scanpath distance. Consistent with the previous results summary, general patterns of visual attention that were common among all participants are reviewed first, followed by a discussion of between-group differences in visual attention.

Because the percentage of time spent fixating, the mean duration of fixations, and the mean scanpath distance are thought to assess different aspects of perceptual processing, it is not surprising that results from these analyses indicate that the effects of participant's role and a topic's cognitive and social demands generally differed depending on which index of visual attention was examined. Interestingly, the percentage of time spent fixating appeared to be the most sensitive to changes in participant's role and topic demands as it yielded the greatest number of significant differences, whereas the mean fixation duration appeared to be the most resilient these changes as it yielded the fewest number of significant differences. It is also notable that compared to the other top-down factors examined in the current study, the effects of an individual's role on patterns of visual attention were the most robust, with significant differences being found between listening and responding portions of interaction for each index of visual attention, regardless of group.

With regard to differences in the percentage of time spent fixating AOIs, results from the current study were consistent with those reported by prior research examining gaze and conversational role (e.g., Turkstra et al, 2003). Specifically, participants in both groups fixated for a greater percentage of time on each region of the confederate's face (eyes, nose, mouth, and face) when listening compared to responding during the interaction. Although these results support the specific prediction made regarding Hypothesis 2, namely that individuals would spend more time fixating the eye region when listening compared to responding, they suggest that this effect of conversational role on visual attention is not unique to the eye region. Indeed, in terms of the magnitude of this effect, a comparison of difference scores for each facial feature indicates that this change was actually greatest for the percentage of time spent fixating the confederate's mouth, followed by his nose, and then his eyes. The significance of the eye region was predicted based on prior research in which eye gaze was manually coded. However, the discrepancy between the current results and those from prior research, which reported that individuals make eye contact approximately 65% of the time while listening and 40% of the time speaking, suggests that visual attention to the eye region, as indicated by eye movements, represents a separate construct from the perception of eye contact (e.g., Turkstra et al, 2003). As such, this finding is important, as it suggests that visual attention does not necessarily map on to how gaze is perceived by observers.

In addition to these differences in the percentage of time spent fixating, listening portions of the interaction were associated with longer mean fixation durations and shorter distances between fixations. Although neither of these indexes of visual attention have been previously compared with regard to whether an individual is listening or speaking, these findings are not surprising given the literature indicating that TD individuals exhibit longer fixation durations and more centralized fixations while viewing audiovisual face stimuli when task difficulty is increased and when facial information is relevant to the task at hand (Buchan et al., 2007; Buchan et al., 2008; Paré, Richler, ten Hove, & Munhall, 2003). Although these studies did not assess scanpath distances, increased fixations to the center of a face would likely be associated with decreased distances between fixations, as fixations between the nose and the eyes, as well as those between the nose and the mouth would invariably be shorter than those between the eyes and the mouth based on the configuration of facial features.

Furthermore, both of the criteria noted above for evoking shorter fixation durations and more centralized fixations appear to be consistent with differences in the demands associated with the listening and responding conditions in the current study. First in terms of task difficulty, the dynamic stimuli viewed during the listening portions of the interaction were likely more demanding to process as the confederate's face was more expressive and more active in terms of facial movements compared to the dynamic stimuli viewed during the responding portions of the interaction. Second, facial information conveyed by dynamic stimuli has been shown to be associated with increased performance during speech perception tasks, and thus would have been beneficial when participants were listening during the interaction (Buchan et al., 2008), whereas the same facial information has been suggested to hinder speech production, and thus, would have been less beneficial when participants were responding (Griffin, 2004). However, because the listening and responding portions of the interaction were highly structured and the interaction was simulated, it will be important for future research to examine whether similar differences in visual attention occur when individuals are listening compared to speaking during live interactions in which these roles are less prescribed.

With regard to the effect of a topic's cognitive and social demands on patterns of visual attention, Hypotheses 4 and 5 predicted that increases in either of these types of demands would be associated with decreases in visual attention to the eyes, though it was expected that for cognitive demands, this effect would be limited to when participants were responding to topics. However, results from the current study do not support these hypotheses or the specific predictions that were based on these hypothesized effects (i.e., Contrasts 4 and 5), as the percentage of time spent fixating the eyes was remarkably stable across topic conditions. Indeed, even with regard to the effect of participant's role described above, only slight differences in the percentage of time spent fixating the eyes were found. Thus, these findings suggest that visual attention to the eyes is generally stable during interactions.

In addition to changes in visual attention to the eye region, Hypothesis 6 predicted that increased cognitive demands would be associated with more centralized gaze when participants were responding, as evidenced by an increase in the percentage of time spent fixating the nose (Contrast 6) and a decrease in the mean scanpath distance (Contrast 7). In general, results from the current study support these hypothesized effects. Specifically, results indicate that when participants recalled positive experiences from their childhood, they spent a greater percentage of time fixating the confederate's nose compared to when recalling recent positive experiences (6.95% vs. 5.28%). In addition, the current study provides tentative support for the prediction regarding mean scanpath distances, as the distance between fixations was shorter when individuals talked about positive, childhood experiences (M=130.24 pixels) compared to positive, recent experiences (M=137.89 pixels). Still, the importance of this difference is unclear, as this change in scanpath distance only approached statistical significance.

However, unexpectedly, results from the omnibus *F*-test suggest that neither changes in the percentage of time spent fixating the nose nor changes in the mean scanpath distance were specific to portions of the interaction when participants responded to topics with high cognitive demands. Rather, these analyses indicate that participants spent a greater percentage of time looking at the nose region when listening to the confederate's responses to topics with high cognitive demands compared to topics with low cognitive demands (14.56% vs. 12.75%), as well as when listening to his responses to topics with high social demands compared to topics with low social demands, though the latter result only approached significance. In addition, when participants were responding to topics with high social demands, the reverse pattern was found, such that individuals looked at the confederate's nose for a smaller percentage of time when talking about negative experiences (4.81%) compared to positive experiences (6.11%). Likewise, results indicate that mean scanpath distances were also influenced by a topic's social demands. Specifically, participants demonstrated shorter scanpath distances when listening to the confederate disclose negative compared to positive experiences (97.36 vs. 103.66 pixels), but longer scanpaths when talking about their own negative experiences compared to positive ones (144.17 vs. 134.06 pixels).

As this study is the first to examine fixations to the nose region and scanpath distances during an interactive task with variable cognitive and social demands, the significance of these findings is unclear. It is possible that these unexpected differences in the percentage of time spent fixating the nose and the mean scanpath distance during listening portions of the interaction could indicate that the confederate's responses for topics with increased cognitive or social demands were more difficult for participants to process. However, it is also possible that theses shifts in gaze served a social function. For example, because both increased fixations to the nose region and decreased scanpath distances resulted in more focused eye movements, these shifts in gaze could be used to communicate increased attention to the confederate's responses, conveying more active or empathic listening. Alternatively, it is possible that these gaze patterns served both perceptual and social functions, as behaviors commonly serve multiple functions and there is no reason why one of these explanations would preclude the other.

Still, the findings regarding decreased fixations to the nose region and increased scanpath distances when participants disclosed negative experiences are notable as a cognitive explanation does not seem to be able to account for these patterns. Specifically, it is unclear why disclosing positive experiences would be more cognitively demanding than disclosing negative experiences. Rather, these findings are more consistent with those from past research indicating that individuals with social anxiety exhibit increased distances between fixations (e.g., Horley et al., 2003), particularly as the experimental procedure used in the current study was in part designed to produce social discomfort during the interaction. Thus, it seems likely that these shifts in gaze were more closely tied to the social demands of the task.

In addition, results from the current study indicate that the combination of a topic's cognitive and social demands had a significant effect on the overall percentage of time participants spent fixating the confederate's face. Relative to low-low topics, participants attended to the confederate's face for a greater proportion of time when topics had either high cognitive demands or high social demands, regardless of their role during the interaction. However, when topics were related to negative, childhood experiences (high-high topics), the percentage of time participants spent fixating the confederate's face did not differ from that exhibited for topics concerning recent, positive experiences (low-low topics). This pattern of results suggests that the recency and the emotional valence of self-disclosures may interact in terms of their effects on memory retrieval (i.e., cognitive demands), topic intimacy (i.e., social demands), or a combination of these two variables. For example, it is possible that individuals experienced greater discomfort when talking about childhood negative experiences compared to recent negative experiences. Conversely, individuals may have found it more difficult to recall specific, negative experiences from their childhood relative to positive experiences from their childhood. As the current study was not designed to explore this interaction in detail, further research is needed to clarify these findings.

Finally, with regard to between-group differences in visual attention, relatively few significant differences were found, and interestingly, none of the differences found were moderated by topic demands during the interaction. Based on past research, it was predicted that significant differences between groups would be found for the percentage of time spent fixating the confederate's eyes, but not for the confederate's face. However, these predicted differences in visual attention were not supported by the current study. Not only was the effect of group not significant, but the mean percentages of time spent looking at the confederate's eyes were also remarkably similar for the two groups. Furthermore it is notable that these results, which were based on gaze data during the entire interaction task, were consistent with those obtained in the previous analysis of the effects of stimulus type on visual attention, which only examined data from the low-low topic conditions. These common null effects suggest that it is unlikely that any between-group differences in visual attention to the eye region were obscured because of co-occurring effects of topic demands. Although no predictions were made for the mouth region, it is also significant that participants in the autism group did not differ from those in the control group in the percentage of time they spent gazing at the confederate's mouth, as studies have suggested that a bias toward information contained by the mouth may underlie decreased gaze to the eyes among individuals with ASD (e.g., Neumann et al., 2006).

For the second part of this prediction, the current study found mixed support for typical face-directed gaze among individuals with ASD. Specifically, individuals with ASD demonstrated decreased gaze to the confederate's face compared to TD individuals, but this difference between groups was only significant during the listening portions of the interaction. Although this finding was unexpected based on the overall body of research examining face processing in autism, research specifically looking at face-directed gaze during interactive contexts has been less clear, with three out of the six studies reporting that individuals with ASD gazed less at their partner's face during an interaction (Doherty-Sneddon et al., 2012; Riby et al., 2012; Tantam et al., 1993). Because of these divergent findings, it will be important for future research to examine whether key methodical differences between the current study and prior research may contribute to whether or not differences in face-directed gaze are found among individuals with ASD. Most notably, the current study differed from past research in terms of the context of the interaction (i.e., video-mediated communication vs. face-to-face communication), the identity of participants' communicative partner (i.e., a confederate posing as a peer vs. an experimenter), and the amount of time participants were required to listen to their partner. Furthermore, because the observed difference between groups was only found for the listening portions of the interaction, the latter difference may be particularly important, as participants in previous studies were only required to listen while the experimenter asked interview questions and thus, were likely much shorter than the listening portions of the interaction during the current study. Still it is important to note that any of these methodological differences, at best, provide a partial explanation for the observed differences between groups in the current study, as further research is needed to clarify why these factors differentially affected gaze patterns in adults with ASD compared to TD adults. Indeed, an argument could be made for each of these methodological differences that the listening portions of the current study resulted in increased cognitive demands, increased social demands, or a combination of increased cognitive and social demands relative to prior research.

Consistent with earlier analyses, significant differences between groups were also found for the percentage of time participants spent fixating the confederate’s nose. As previously noted, gaze to the nose region has rarely been examined in studies of face processing in individuals with ASD. However, research with TD individuals provides indirect evidence that fixations to the nose region are important during both audiovisual speech perception and face recognition tasks, as individuals tend to fixate the nose first and spend a greater amount of time fixating the nose region when task difficulty is increased (e.g., Hsiao & Cottrell, 2008; Buchan et al., 2008). Additional, more direct evidence for the importance of gaze to the nose region is provided by a study by Peterson and Eckstein (2012) that assessed the distribution of fixations to faces during different face processing tasks and then examined how these patterns fit with various computational models. In addition to replicating previously reported patterns of gaze directed at the nose region, results from this study indicated that only a model which predicted fixations based on maximizing the amount of discriminating information within the fovea was reliably able to predict the observed distribution of fixations, whereas models based on a central bias strategy, which predicted fixations based on the center of the face, head, or screen, were not consistent with observed patterns of gaze. As such, Peterson and Eckstein (2012) were able to directly show that fixations to the nose region optimized the processing of visual information within faces.

Thus, it is possible that in the current study, the smaller proportion of time spent fixating the nose represents an attenuated tendency for individuals with ASD to scan faces based on optimizing foveal information. Unfortunately, this tendency has not been explored from a developmental perspective, and thus, it is unclear what role developmental and experiential factors play in establishing this optimal fixation strategy for faces. In addition, it is important to note that prior research on visual attention to the nose region has assessed gaze during passive viewing conditions, whereas, the current study examined it within an interactive context, albeit a simulated one. Because gaze during interactions serves both social and perceptual functions, it is not possible to rule out alternative social explanations for this difference at this time. As a result, it will be important for future research to examine the significance of visual attention to the nose region during interactive, social contexts and to explore any social functions that could also contribute to increased gaze to this region. In particular, future research should consider how fixations to the eyes and nose are related to more nuanced types of gaze behaviors (e.g., soft or supportive gaze, staring), both in terms of how certain fixation patterns are experienced by the individual directing gaze (i.e.,, the gazer) and in terms of how these fixation patterns are perceived by observers.

In addition to differences in the percentage of time spent fixating AOIs, between-group differences were predicted for both the mean fixation duration and the mean scanpath distance based on the predominant explanations for face processing impairments in individuals with ASD. Specifically, it was predicted that the autism group would exhibit longer mean fixation durations relative to the control group, as it has been theorized that individuals with ASD are less efficient at processing faces. However, results from current study suggest that individuals with ASD exhibit fixations which are similar in length to those exhibited by TD individuals. Although it is possible that this null finding could reflect a failure among individuals with ASD to use compensatory strategies when tasks are more difficult, such as increased mean fixation durations, no performance measure was assessed in the current study and thus, this possibility cannot be directly evaluated. However, the fact that participants with ASD did exhibit longer mean fixation durations when listening compared to responding during the interaction indicates that this compensatory strategy cannot be altogether absent. Alternatively, it is possible that the perceptual processing required during the current study was not sufficiently demanding to reveal differences in the efficiency in which individuals with ASD process facial information. As a result, it will be important for future studies to also manipulate the perceptual complexity of face stimuli in order to better understand how individuals with ASD attend to dynamic, interactive faces.

With regard to scanpath distances, there is evidence, albeit limited, that featural processing is characterized by a greater number of within-feature fixations and by less extensive scanning of faces compared to configural processing (Bombari et al., 2009; Schwarzer et al., 2005). If so, this would suggest that shorter scanpath distances represent a greater emphasis on featural processing, as consecutive fixations within a feature would on average be closer together than fixations across features; conversely, longer scanpath distances would represent a shift toward more configural processing. As a result, individuals with ASD were predicted to exhibit shorter distances between fixations.

However, results from the current study provide mixed support for this hypothesized effect, with participants in the autism group exhibiting more proximal fixations relative to those in the control group, but only during responding portions of the interaction. Interestingly, a comparison of the means between groups and participant's role conditions suggests that this pattern of effects resulted primarily from a shift in how TD individuals scanned stimuli during the responding compared to the listening portions of the interaction, rather than a shift in how individuals with ASD scanned stimuli. Although as indicated above, all participants exhibited longer scanpath distances when responding, this difference was attenuated in the autism group, suggesting that scanpath distances in individuals with ASD are more stable. Thus when listening, both groups tended to demonstrate fixations that were relatively close together, such as within features. However when responding, participants in the autism group appear to have persisted with this strategy, whereas participants in the control group exhibited a greater increase in mean scanpath distances, suggesting that they shifted from this strategy and more broadly sampled visual information from the confederate's face. Still, it is important to note this interpretation is not conclusive, as mean scanpath distances in the current study are only hypothesized to serve as a proxy for the number of within-feature versus across-feature fixations.

7.4 INDIVIDUAL DIFFERENCES IN VISUAL ATTENTION

The relationship between six indexes of visual attention (the percentage of time spent fixating the confederate's face, the mean fixation duration to the confederate's face, and the mean scanpath distance, each calculated separately for listening and responding conditions) and individual differences in IQ (FSIQ, VIQ, and PIQ), autism symptomology (ADOS scores and SRS total), and social anxiety (SPAI-23 difference scores) were assessed using Pearson's correlations matrixes. As shown in Table 12, significant correlations between each measure of IQ and the percentage of time spent fixating the confederate's face were found for all participants; however, these correlations did not remain significant after adjusting *p* values for multiple comparisons (*p*s>.05).

Table 12. Correlations between Measures of IQ, Social Anxiety, and Indexes of Visual Attention Depending on Participant's Role for All Participants (*n*=38)

	VIQ		PIQ		FSIQ		SPAI-DS	
Variable	*r*	Unadj. *p*	*r*	Unadj. *p*	*r*	Unadj. *p*	*r*	Unadj. *p*[a]
%Face								
Responding	-0.35	.031	-0.35	.030	-0.38	.020	-0.39	.007*
Listening	-.20	.235	-.14	.387	-.17	.319	-.18	.140
Avg. Fixation Duration								
Responding	-.22	.180	-.24	.142	-.25	.125	-.17	.159
Listening	-.06	.727	-.10	.570	-.08	.616	-.09	.288
Avg. Scanpath Distance								
Responding	.12	.486	0.35	.032	.25	.124	.12	.236
Listening	.08	.623	.13	.427	.12	.463	.14	.200

Note. Unadj. *p*= *p* value prior to FDR correction for multiple comparisons.
[a]Unadjusted *p*-value based on one-tailed significance test.
**p<.05* after correcting for multiple comparisons.

There was also a significant correlation between symptoms of social anxiety and the percentage of time spent fixating the confederate's face during the responding condition, such that increases in the amount of social anxiety symptoms endorsed was associated with decreased face-directed gaze (r=-.39, p=.04). This indicated that self-reported social anxiety symptoms on the SPAI-23 had a medium effect on the percentage of time that participants spent fixating the confederate's face while responding to topics during the interaction, accounting for approximately 15% of the variance among participants' gaze. When correlations were calculated separately for the autism group and the control group, this association remained significant (control group: *r*=-.46, *df*=19, *p*=.023; autism group: *r*=-.42, *df*=19, *p*=.039), indicating that the overall correlation was not driven by either group. In addition, no significant correlations were found between self-reported social anxiety symptoms and ADOS communication scores (*r*=.22, *df*=19, *p*=.372), social scores (*r*=-.28, *df*=19, *p*=.247), or combined scores (*r*=-.28, *df*=19, *p*=.238), suggesting that the symptoms assessed by the SPAI-23 were independent of autism symptoms.

For the autism group, correlations between measures of autism symptoms and indexes of visual attention yielded a significant correlation between ADOS communication scores and mean fixation durations while responding during the interaction, with greater communication impairments being associated with shorter mean fixation durations to the confederate's face; however, this correlation did not remain significant after adjusting for multiple comparisons (r=-.40, df=19, p=.382). No other significant associations were found between any of the variables (ps>.05; see Appendix I for a summary of Pearson correlation coefficients and unadjusted p values for these analyses).

7.4.1 Subgroup analyses

In addition to the planned analyses examining individual differences in gaze, exploratory analyses were conducted examining the association between prior participation in a social skills intervention and patterns of visual attention to the confederate's face. No analyses were initially planned to examine this association as it was anticipated that the majority of participants in the autism group would have previously participated in a social skills intervention. However, only a little over half of participants in the autism group (11 out of 19) reported having participated in a social skills intervention, which made it possible to compare patterns of visual attention in this subset of participants (ASD-Social Intervention) to that of participants in the autism group who had not participated in a social skills intervention (ASD-No Intervention), as well as to that of participants in the control group. Specifically, analyses examining the effect of stimulus type (static, D-List, D-Resp) on patterns of visual attention were rerun to explore differences among these three groups for the percentage of time spent fixating the confederate's face[3] and for the mean fixation duration.

Participant characteristics for the two autism subgroups are shown in Table 13 (characteristics are not shown for the control group as they did not differ from those reported in previous analyses). Prior to running this subgroup analysis, a MANOVA was conducted to examine whether differences in the original matching characteristics existed among the three groups. Results indicated that the three groups did not differ with respect to mean age (p=.962), FSIQ (p=.695), PIQ (p=.683), VIQ (p=.759), or SPAI-23 Difference Score (p=.432).

[3] In order to decrease the number of comparisons made in this exploratory, subgroup analysis, only visual attention to the Face AOI was examined, as prior analyses indicated that this region was associated with group differences in visual attention depending on the stimulus type. Although, prior analysis of stimulus type also revealed between-group differences in %Nose, the nose region was not examined as it was not shown to interact with stimulus type and it provided more limited information regarding how participants attended to face stimuli.

Table 13. Characteristics of Participants in the Autism Group Depending on Prior Participation in a Social Skills Intervention

Variable		No Intervention (*n*=8) *M(SD)*	Social Intervention (*n*=11) *M(SD)*
Age		27.25 (6.11)	27.45 (8.05)
VIQ		112.50 (16.93)	109.64 (13.30)
PIQ		113.25 (17.43)	110.09 (17.25)
FSIQ		114.88 (18.74)	111.36 (15.12)
SPAI-23		20.38 (7.03)	20.00 (8.88)
ADOS Com.		4.38 (1.19)	3.09 (0.83)
ADOS Soc.		9.00 (3.02)	7.09 (1.81)
ADOS Com.Soc.		13.38 (3.82)	10.18 (2.31)
%Mouth / %Eyes			
	Static	10.51/47.95 (14.73/25.47)	8.38/27.15 (9.07/26.50)
	D-Resp	1.27/3.73 (2.38/4.31)	5.21/5.41 (5.43/9.66)
	D-List	11.32/10.22 (12.90/7.36)	18.04/6.74 (11.82/6.97)

Note. VIQ=Verbal IQ; PIQ=Performance IQ; FSIQ=Full Scale IQ; ADOS Com. = ADOS communication score; ADOS Soc. = ASDOS Social Score; ADOS Com.Soc.= ADOS Combined Score (Communication + Social); D-Resp=Dynamic:Responding; D-List=Dynamic:Listening.

In addition, a series of independent *t* tests were conducted to examine whether differences in ADOS scores existed between the two autism groups. Results indicated that participants in the ASD-Social Intervention group had significantly lower ADOS communication scores compared to participants in the ASD-No Intervention group, $t(17)=2.78$, $p=.013$. There was also a nonsignificant trend such that ADOS combined scores were lower for the ASD-Social Intervention group compared to the ASD-No Intervention group, $t(10.72)=2.10$, $p=.060$. Although %Eyes and %Mouth were not examined in the subgroup analysis, means and standard deviations for these two indexes of visual attention are also included for each stimulus type in Table 13, in order to explore whether either subgroup demonstrated preferential attention to the mouth region compared to the eye region. As can be seen, neither subgroup demonstrated a bias for the mouth region, except when viewing D-List stimuli, during which the control group also demonstrated a similar bias (i.e., Mouth: 20.53% vs. Eyes: 9.96%).

For the percentage of time spent fixating the confederate's face, results of the 3(Group) x 3 (Stimulus Type) ANOVA revealed a significant main effect of stimulus type, $F(1.92, 67.03)=156.30$, $p<.001$. Consistent with earlier analyses, participants spent the greatest percentage of time fixating the confederate's face during the static condition (M=82.37%), followed by the D-List condition (M=58.03%), and then the D-Resp condition (M=21.27%). Post-hoc contrasts indicated that each condition differed significantly from the other two (ps<.05). There was also a significant main effect of group, $F(2,35)=5.13$, $p=.011$. Follow-up, independent t tests revealed that overall, participants in the ASD-No Intervention group looked at the confederate's face for a smaller percentage of time (M=45.04%) compared to participants in the control group (M=61.59%), $t(25)= 3.18$, $p= .003$. There was also a nonsignificant trend when comparing the ASD-Social Intervention group to the ASD-No Intervention group, with participants who participated in a social skills intervention spending a greater percentage of time looking at the confederate's face (M=55.04%) relative to those participants who had not, $t(17)=1.75$, $p=.090$. In contrast, the overall percentage of time spent fixating the confederate's face did not differ between the control group and the ASD-Social Intervention group, $t(28)=1.40$, $p=.170$.

In addition, there was a significant Group X Stimulus Type interaction, $F(3.83, 43.31)=3.46$, $p=.014$. Follow-up, one-way ANOVAs were conducted to examine differences among the three groups for each type of stimulus. As show in Figure 10, all three groups spent a similar percentage of time fixating the confederate's face when shown a static stimulus, $F(2, 35)=0.65$, $p=.531$. However, there was a significant difference among groups when viewing the confederate's face during the D-List condition, $F(2, 35)=7.59$, $p=.006$. Post-hoc comparisons indicated that participants in the control group spent a significantly greater percentage of time fixating the confederate's face than participants in the ASD-No Intervention group, $t(25)=4.85$, $p<.001$. In contrast, the ASD-Social Intervention group did not differ significantly from either the control group or the ASD-No Intervention group (*p*s>.05). Finally for the D-Resp condition, there was a nonsignificant trend after adjusting for multiple comparisons for the effect of group, $F(2, 35)=3.33$, $p=.071$. Follow-up comparisons indicated that again, the control group spent a greater percentage of time fixating the confederate's face than the ASD-No Intervention group, $t(25)=2.92$, $p=.021$. However, results indicated that the ASD-Social Intervention group also spent a greater percentage of time fixating the confederate's face compared to the ASD-No Intervention group, $t(13.84)=2.37$, $p=.049$. Finally, as with the other types of stimuli, the control group did not differ from the ASD-Social Intervention group with regard to the percentage of time spent fixating the confederate's face during the D-Resp condition, $t(28)=0.19$, $p=.852$.

In contrast, for mean fixation durations, results of the 3(Group) x 3 (Stimulus Type) ANOVA yielded a significant main effect of stimulus type, $F(1.16, 39.60)=4.66$, $p=.032$. However, no other significant differences were found (*p*s>.05). Because these findings mirrored those described in the previous analysis examining the effects of stimulus type on mean fixation durations based on two groups (control vs. autism), results from this analysis are not discussed further as they would duplicate those already reported.

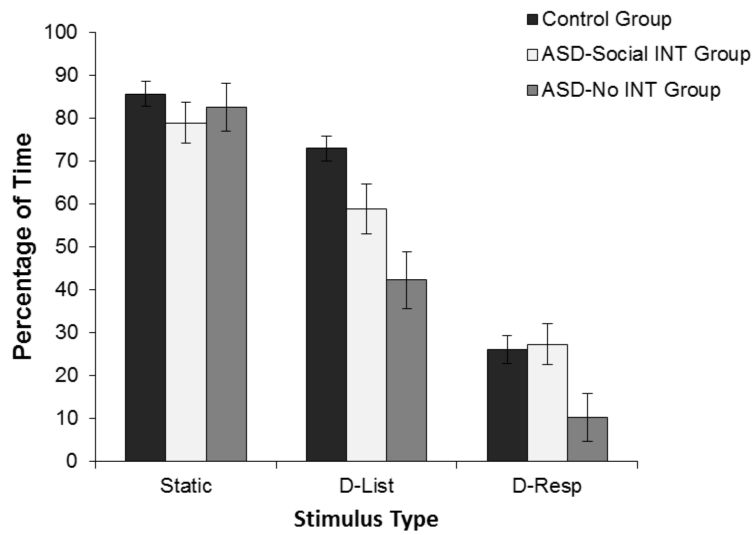

Figure 10. Percentage of time spent fixating the confederate's face depending the type of stimulus viewed for the control group, the ASD-Social Intervention group (ASD-Social-INT), and the ASD-No Intervention group (ASD-No INT). Error bars represent standard error.

7.4.2 Summary and discussion of results: Individual differences in visual attention

Results from the current study, as well as those from past research, indicate that there is substantial variability in patterns of visual attention to faces among both individuals with and without ASD (Peterson & Eckstein, 2013a; Rice et al., 2012). As a result, the current study sought to clarify whether individual differences in IQ, social anxiety, or autism symptoms were associated with differences in visual attention to faces during an interactive context. Consistent with past research, social anxiety symptoms endorsed on the SPAI-23 were significantly correlated with the percentage of time participants spent gazing at the confederate's face (Corden et al., 2008). Specifically, increases in self-reported symptoms were associated with decreases in visual attention for participants in both the autism group and the control group; however, this association was limited to portions of the interaction when participants were required to talk about their own experiences. In addition, results from these analyses provide further evidence that social anxiety can be disassociated from autism symptoms, as social anxiety ratings were not correlated with any measure of autism symptoms (Corden et al., 2008). In contrast, no measure of autism symptoms was associated with any of the indexes of visual attention examined. However, this is not surprising as such associations have been inconsistently found by past research (e.g., Klin et al., 2002; Norbury et al., 2009). For example, in a large sample of children with ASD, Rice and colleagues (2012) found that patterns of visual attention were only negatively associated with autism symptoms for children with specific cognitive profiles. Thus, it seems likely that sample sizes significantly larger than those in the current study are needed to reliably characterize associations between autism symptoms and patterns of visual attention to dynamic, interactive faces.

Despite these nonsignificant associations between autism symptoms and gaze, analysis of autism subgroups based on prior participation in a social skills intervention suggests that meaningful differences in patterns of visual attention exist among individuals with ASD. Specifically, when the effects of stimulus type on the percentage of time spent fixating the confederate’s face were re-examined only with participants in the autism group split into two subgroups (i.e., ASD-Social Intervention group and ASD-No Intervention group), differences in the expected direction were found for the D-Resp condition, but only for those participants who reported that they had not participated in a social skills intervention. Results indicated that when responding during the interaction, participants in the autism group who *had* participated in a social skills intervention spent a similar percentage of time fixating the confederate’s face as participants in the control group (~26% vs. ~27%). In contrast, participants in the autism group who *had not* participated in a social skills intervention fixated the confederate's face for a smaller percentage of time (~10%) relative to both participants in the control group and participants in the ASD-Social Intervention group. Interestingly, the three groups were more clearly disassociated from each other during the listening portions of the interaction, with a nonsignificant trend indicating that participants in the control group spent the greatest percentage of time fixating the confederate's face, followed by participants in the autism group who had participated in a socials skills intervention, and then by participants in the autism group who had not participated in a social skills intervention. However, consistent with previous analyses, mean fixation durations did not differ among groups.

Given the small sample sizes for the two autism subgroups, further replication and clarification of these findings will be important. Still, these results suggest that the tendency for individuals with ASD to exhibit less face-directed gaze during interactions may be attenuated through participation in social skills interventions and thus, should be more directly examined using a pre-post design. If so, this would suggest that individuals with ASD may benefit from the explicit direction to look others in the eyes (which was reportedly given to all participants except for one) or the opportunity to practice making eye contact, both of which are commonly incorporated into social skills interventions. However because these analyses relied on self-report data and did not randomly assign participants to the autism subgroups, systematic differences in the compositions of these two subgroups (e.g., between-group differences in communication skills) may have contributed to the observed differences in gaze, rather than prior participation in a social skills intervention. Thus, it will be important for future studies to not only directly examine the effects of social skills interventions on visual attention to faces but also to identify characteristics of interventions that may mediate any differences that are found.

7.5 EXPLORATORY FRAME-BY-FRAME ANALYSES

Temporal-specific, between-group differences in viewing proportion were examined for listening portions of the interaction. Based on the data reduction method outlined in the methods section, 54 critical periods were identified for analysis across the eight stimuli that were randomly selected. Out of these critical periods, only two pertained to time periods during the interaction when the viewing proportion was greater for the autism group compared to the control group. The distribution of critical periods also differed depending on the facial feature examined. Specifically, the majority of critical periods were identified for the Nose AOI (n=34), followed by the Mouth AOI (n=16), and then by the Eyes AOI (n=4). Results from a chi-squared test indicated that this distribution deviated from what would be expected based on chance, X^2=25.33 df=2, p<.001. Follow-up comparisons indicated that significantly more critical periods were identified for the Nose AOI compared to either the Eyes AOI (X^2=23.68, df=1, p<.001) or the Mouth AOI (X^2=6.48, df=1, p=.011). Similarly, more critical periods were identified for the Mouth AOI relative to the Eyes AOI, X^2=7.20 df=1, p=*.010*.

With regard to differences among topics, the fewest number of critical periods were identified for low-low topics (n=10). However, the number of critical periods identified were relatively similar across the remaining types of topics (high cognitive topics: n=14; high social topics: n=15; high-high topics: n=15). Consistent with this visual inspection, results from a chi-square analysis indicated that the distribution of identified critical periods did not significantly differ among topic conditions, X^2=1.26, *df*=3, *p*=.74.

As can be seen in Table 14, Mann-Whitney *U* tests yielded significant differences between groups for 15 of the 54 comparisons initially identified, all of which reflected time periods during which the viewing proportion was greater for the control group compared to the autism group. The distribution of significant critical periods across AOIs followed the distribution of identified critical periods, with the majority of significant differences being found for the Nose AOI (*n*=9), followed by the Mouth AOI (*n*=4), and then by the Eye AOI (*n*=2). Despite this, it is interesting to note that the eye region had the greatest percentage of significant differences relative to identified critical periods, as 50% of the critical periods identified were found to be significant. In contrast, 26.47% of the critical periods identified for the nose region and 25% of those identified for the mouth region were significant. However, because of the small number of identified and significant critical periods, particularly for the eye region, it was not possible to assess whether this pattern represented a reliable finding. Likewise, there was no clear pattern among significant critical periods in terms of topic conditions given the small sample size.

Table 14. Statistical Significance of Between-Group Differences in Viewing Proportions for Critical Periods Identified for Topics and AOIs

AOI	Comparison[a]	Critical Period[b]	*n*	*U*	Unadj. *p*	Adjusted Sig.
Describe something you can do well and feel confident about doing. (Low – Low topic)						
Eyes	1	17.316 - 17.982	6	0.00	0.10	ns
Nose	1	8.658 - 9.324	6	0.00	0.10	ns
	2	11.322 - 13.986	18	0.00	0.00	***
Mouth	1	0.999 - 1.665	6	0.50	0.20	ns
	2	5.328 - 6.327	8	0.00	0.03	ns
	3	19.314 - 20.313	8	0.00	0.03	ns
Share a time when you felt happy during the past week. (Low – Low topic)						
Eyes	NA	NA	-	-	-	-
Nose	1	15.318 - 15.984	6	0.00	0.10	ns
	2	17.982 - 18.981	8	0.00	0.03	ns
Mouth	1	1.332 - 2.997	12	0.00	0.00	**
	2	4.329 - 6.327	14	0.00	0.00	***
Tell about a time when you were a child, and you felt proud of yourself. (High Cognitive topic)						
Eyes	NA	NA	-	-	-	-
Nose	1	0.999 - 1.998	8	0.00	0.03	ns
	2	4.662 - 5.661	8	0.00	0.03	ns
	3	8.325 - 9.657	10	0.00	0.01	ns
	4	19.314 - 19.98	6	0.00	0.10	ns
	5	20.979 - 21.645	6	0.00	0.10	ns
Mouth	1	2.331 - 3.33	8	0.00	0.03	ns
	2	12.987 - 13.653	6	0.00	0.10	ns
Describe an exciting trip or vacation that you went on as a child. (High Cognitive topic)						
Eyes	NA	NA	-	-	-	-
Nose	1	2.331 - 3.663	10	0.00	0.01	*
	2	4.9956.327	10	0.00	0.01	*
	3	7.6599.99	16	0.00	0.00	**
	4	13.986 - 15.651	12	0.50	0.00	*
	5	16.650 - 17.316	6	0.00	0.10	ns
	6	17.982 - 19.98	14	0.00	0.00	**
Mouth	1	10.323 - 11.655	10	0.00	0.01	*
Describe a time in the last week when you felt annoyed or irritated. (High Social topic)						
Eyes	1	6.66 - 7.326	6	0.00	0.10	ns

AOI	Comparison[a]	Critical Period[b]	*n*	*U*	Unadj. *p*	Adjusted Sig.
Nose	1	0.999 - 1.665	6	0.00	0.10	ns
	2	10.989 - 11.655	6	0.00	0.10	ns
	3	15.984 - 16.65	6	0.00	0.10	ns
Mouth	1	4.662 - 5.328	6	0.00	0.10	ns
	2[c]	23.31 - 23.976	6	0.00	0.10	ns
Describe a time when you were nervous or afraid in the last year. (High Social topic)						
Eyes	NA	NA	-	-	-	-
Nose	1	0.000 - 0.666	6	0.00	0.10	ns
	2	2.331 - 3.33	8	0.00	0.03	ns
	3	5.328 - 5.994	6	0.00	0.10	ns
	4	8.991 - 9.99	8	0.00	0.03	ns
	5	21.978 - 22.644	6	0.00	0.10	ns
	6	28.971 - 30.303	10	0.00	0.01	ns
Mouth	1	16.983 - 17.982	8	0.00	0.10	ns
	2	19.647 - 20.979	10	0.00	0.03	ns
	3[c]	24.642 - 25.308	6	0.00	0.10	ns
Share a time when you were a child and had your feelings hurt. (High – High topic)						
Eyes	1	19.314 - 20.979	12	0.00	0.00	**
	2	21.645 - 23.643	14	0.00	0.00	**
Nose	1	4.662 - 8.325	24	0.00	<.001	***
	2	14.319 - 14.985	6	0.00	0.10	ns
	3	15.984 - 19.647	24	0.00	<.001	***
	4	22.311 - 22.977	6	.500	.200	ns
Mouth	NA	NA	-	-	-	-
Describe a time when you remember feeling angry as a child. (High – High topic)						
Eyes	NA	NA	-	-	-	-
Nose	1	6.327 - 7.992	12	0.00	0.00	*
	2	11.988 - 13.32	10	0.00	0.01	ns
	3	17.649 - 18.648	8	0.00	0.03	ns
	4	20.646 - 21.645	8	0.00	0.03	ns
	5	24.309 - 24.975	6	0.00	0.10	ns
	6	28.638 - 29.304	6	0.00	0.10	ns
Mouth	1	0.666 - 3.33	18	0.00	0.00	***
	2	14.652 - 15.318	6	0.00	0.10	ns
	3	21.978 - 22.644	6	0.00	0.10	ns

Note. Topic prompt shown in bold and type of topic shown in parentheses; Unadj. *p*=unadjusted p; Adjusted Sig.=adjusted significance using Holm-Bonferoni correction for multiple comparisons; ns=nonsignificant.
[a]Index of the number of between-group comparisons made for each AOI within a topic.
[b]Timestamp in seconds marking the onset and offset of a critical period within a video.
[c]Comparisons in which the viewing proportion was greater for the autism group than the control group.
*p<.05. **p<.01. ***p<.001

The proportions of participants viewing the Eyes, Nose, and Mouth AOIs over time are shown in Figures 11-15 for each stimulus in which at least one significant critical period was found, with shaded areas indicting time periods in which viewing proportions differed significantly between groups (*p*s>.05). Viewing proportions for the three stimuli that did not yield any significant critical periods can be viewed in Figures J1-J3. However prior to describing the contextual factors associated with these significant critical periods, three general patterns are worth noting. First, as can be seen in Figures 11-15, temporal viewing patterns between-groups appeared to be relatively similar. Indeed, peaks and dips in the proportion of participants in the control group viewing a given AOI were often mirrored by those in the autism group. Although there were several instances in which the viewing proportions differed significantly between groups, viewing patterns for the autism group did not appear to be grossly atypical. Second, both groups showed temporal fluctuations in what part of the confederate's face participants were viewing. Moreover, visual inspection of the data did not reveal any striking temporal patterns in terms of how participants distributed their attention, thus, highlighting the complex and dynamic nature of gaze. Finally, it is important to note that the proportion of participants viewing an AOI during a specific time interval infrequently exceeded .5 for either the autism group (0.37% of time bins) or the control group (3.16% of time bins), suggesting that there is significant variability in where individuals are looking from moment-to-moment, at least with regard to the time scale examined in the current study.

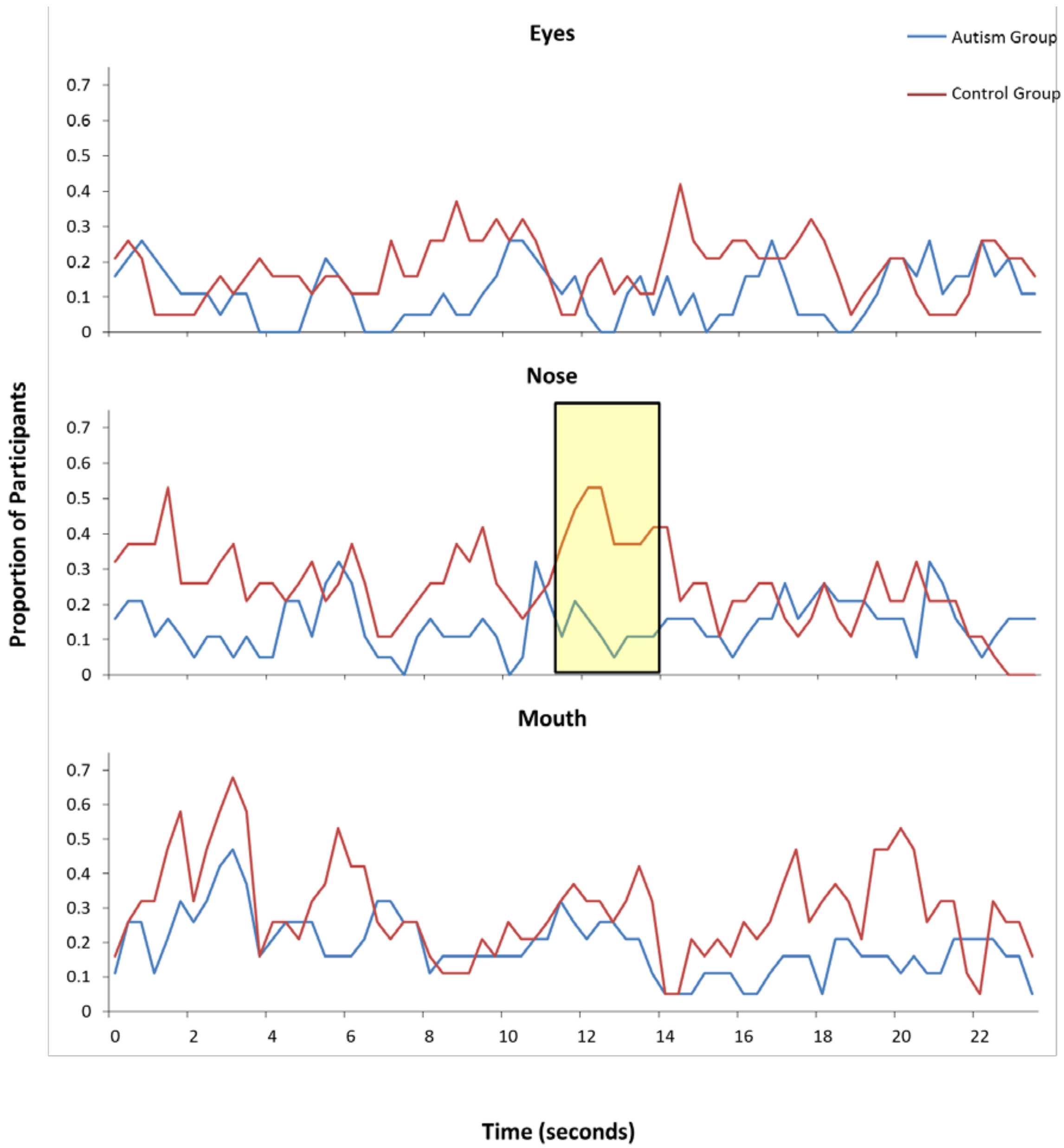

Figure 11. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a Low-Low topic, "Describe something you can do well and feel confident about doing." Shaded areas represent critical periods during which significant group differences were found.

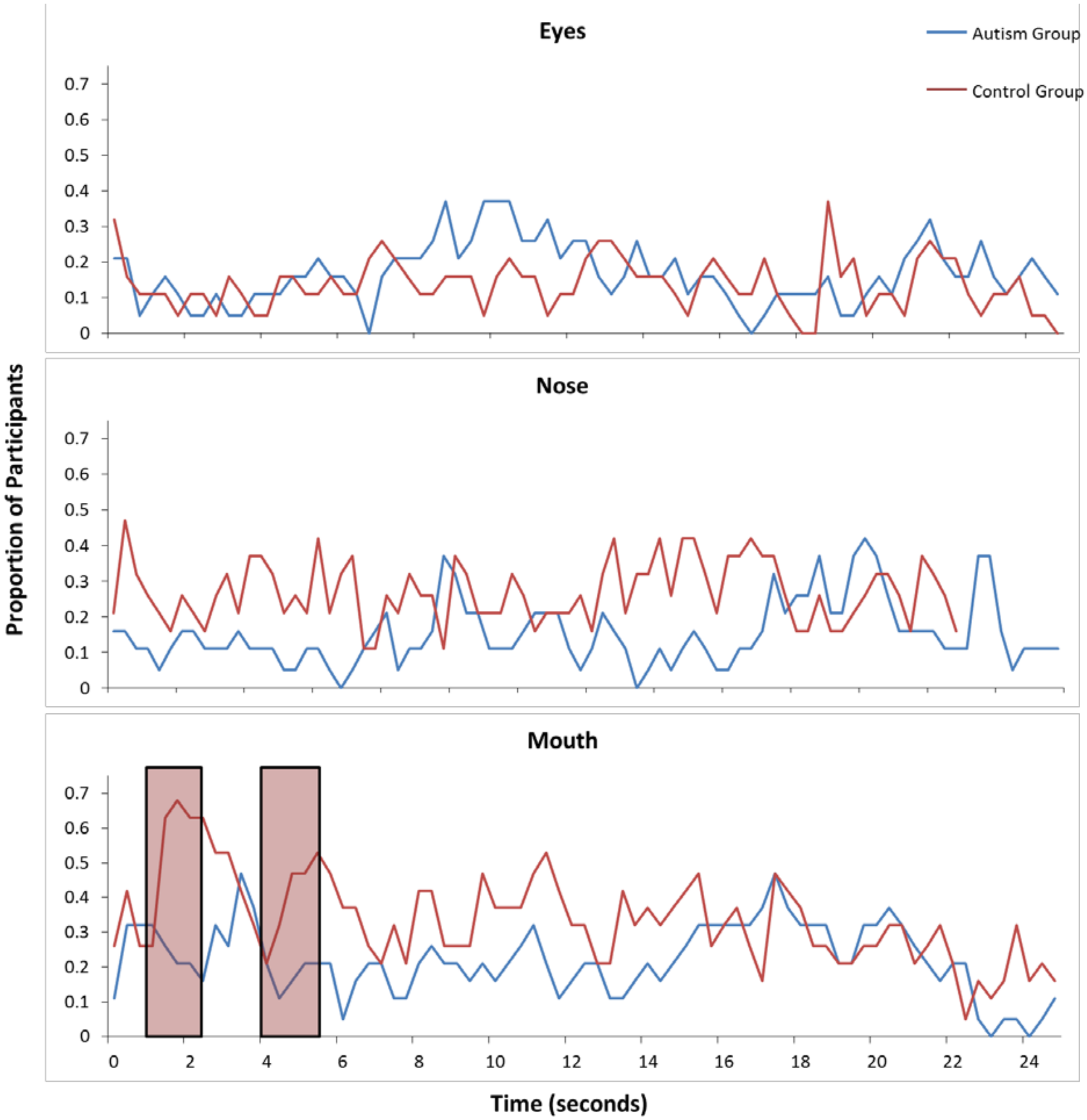

Figure 12. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a Low-Low topic, "Share a time that you felt happy during the past week." Shaded areas represent critical periods during which significant group differences were found.

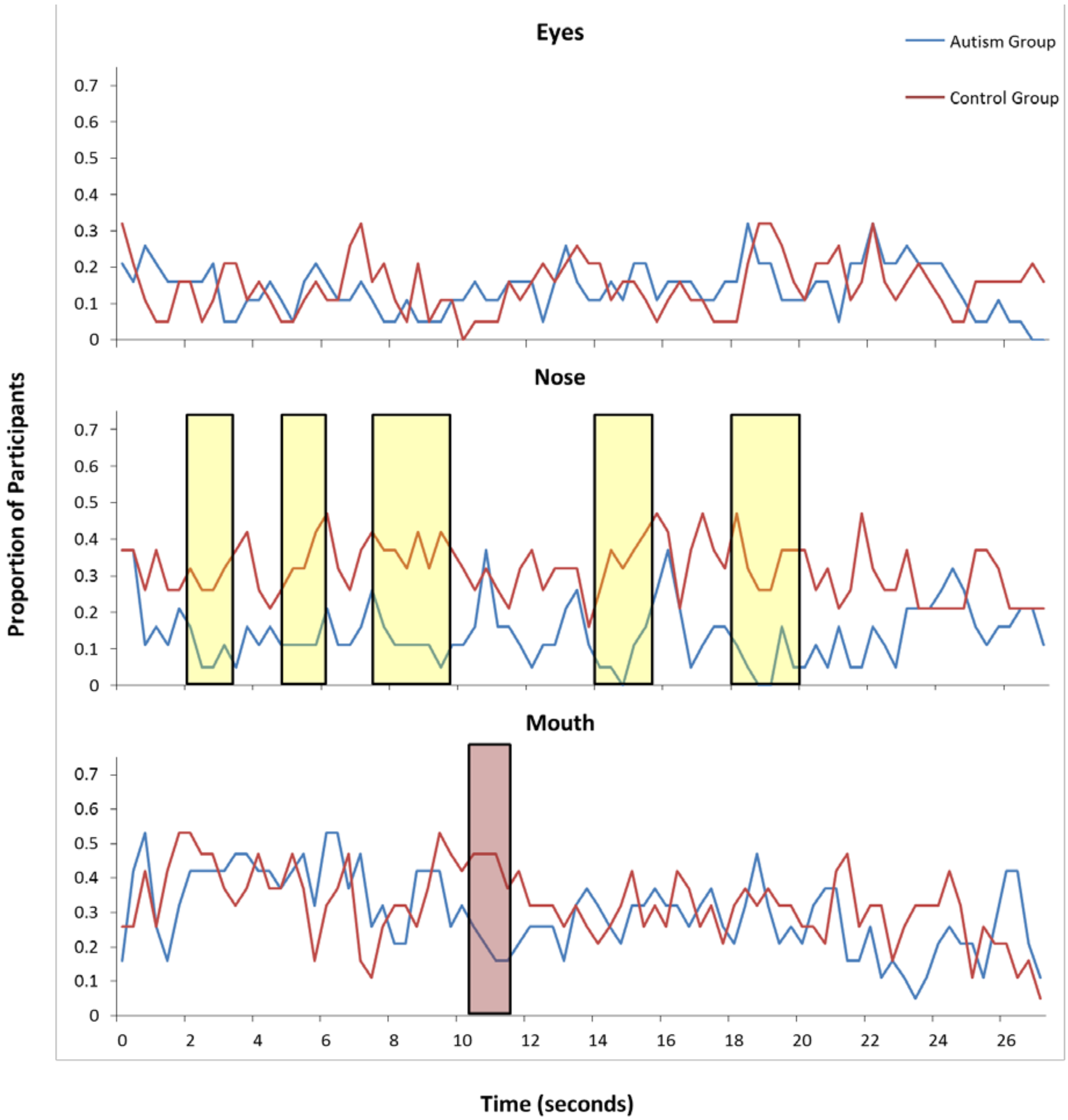

Figure 13. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a High Cognitive topic, "Describe an exciting trip or vacation that you went on as a child." Shaded areas represent critical periods during which significant group differences were found.

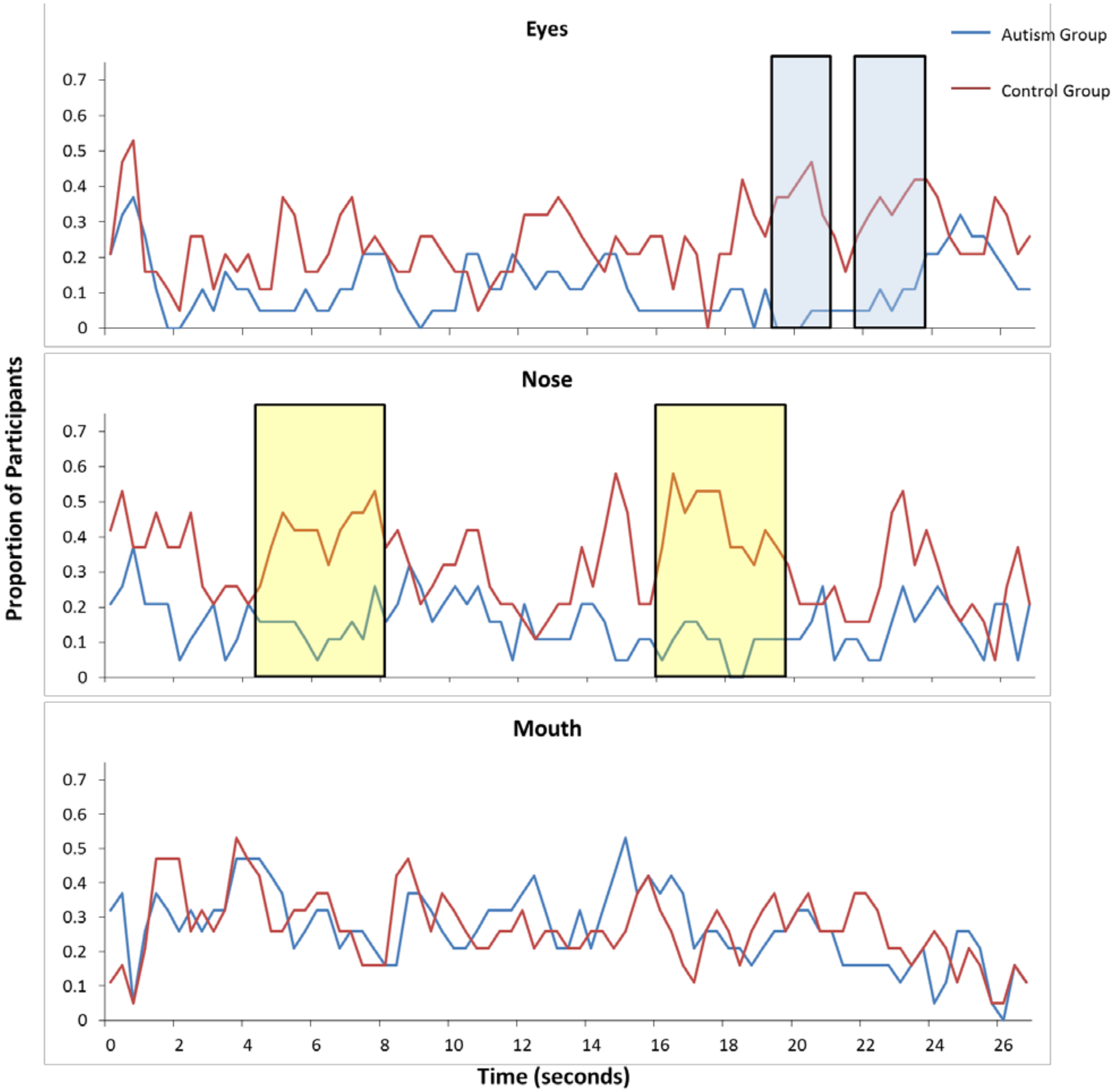

Figure 14. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a High-High topic, "Share a time when you were a child and had your feelings hurt." Shaded areas represent critical periods during which significant group differences were found.

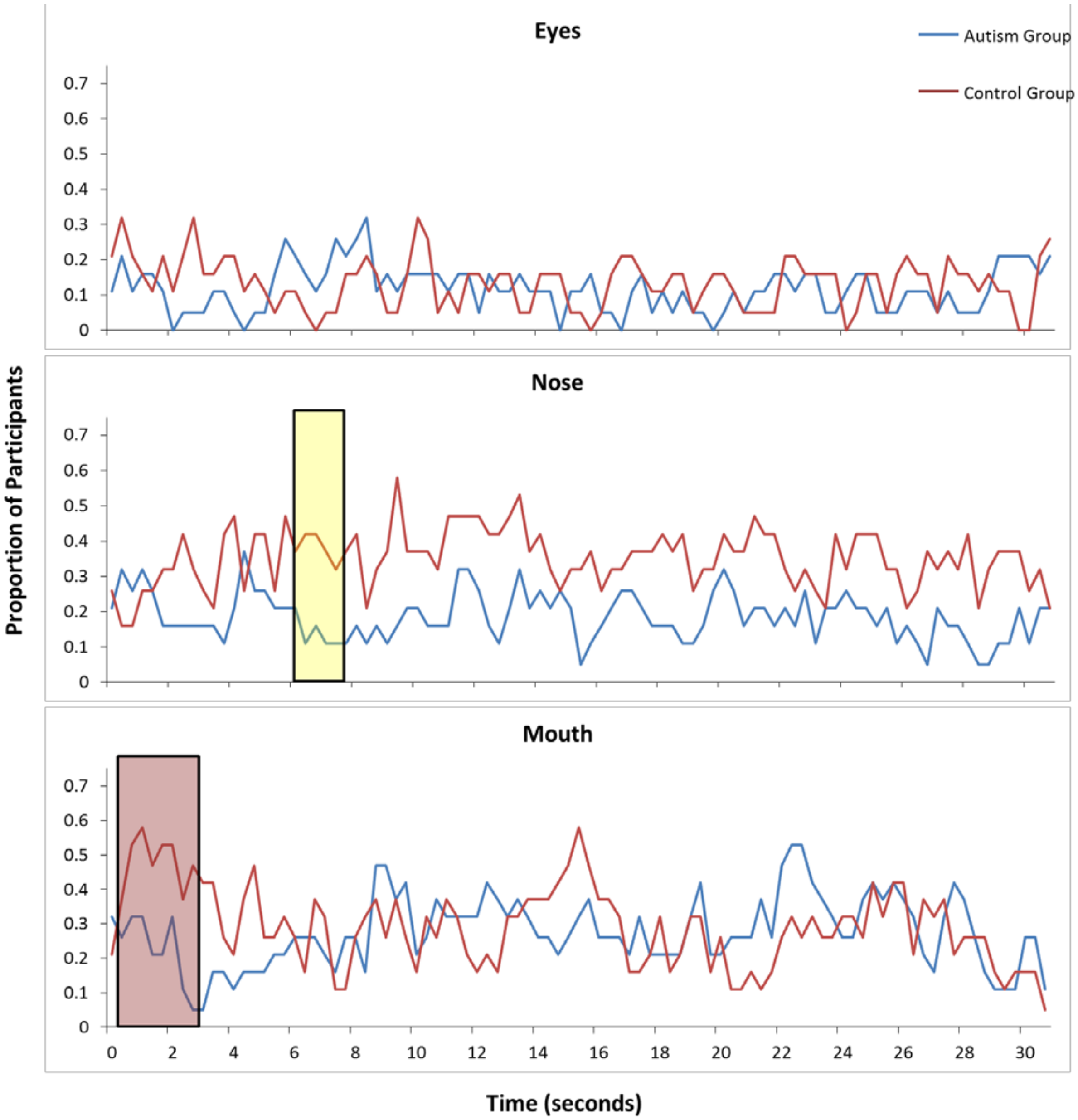

Figure 15. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a High-High topic, "Describe a time when you remember feeling angry as a child." Shaded areas represent critical periods during which significant group differences were found.

To explore contextual factors associated with significant critical periods, the confederate's speech during each significant critical period, as well as during the preceding two seconds was transcribed and is shown in Table 15 (for full transcriptions of the confederate's responses to the topics that were selected for the frame-by-frame analysis, see Appendix K). Although the confederate's responses occasionally included gestures, none of the significant critical periods corresponded with instances of gesturing, and thus, differences in viewing proportions were not able to be examined for gestures.

As noted above, frame-by-frame analysis of the proportion of participants viewing the confederate's eyes revealed relatively few instances during which the two groups differed, both in terms of qualitative differences (i.e., the number of critical periods identified) and quantitative differences (i.e., the number of significant critical periods found). However, review of the contextual factors associated with the two significant critical periods indicated that both of these periods occurred when the confederate was responding to the topic, "Share a time when you were a child and had your feelings hurt" (see Figure 14). For this topic, the confederate described a time when he was teased by his classmates after doing an oral presentation. Results indicated that both significant critical periods coincided with moments during the confederate's response in which he mentioned negative feelings (i.e., "hurt my feelings," and "pretty embarrassed"), with a significantly greater proportion of participants in the control group fixating the confederate's eyes compared to the autism group (critical period_1: M=.37 vs. M=.03; critical period_2: M=.35 vs. M=.10). Thus, despite the limited sample of significant critical periods for the eye region, between-group differences in viewing proportion appeared to be associated with emotional speech.

Table 15. Transcription of Confederate's Speech for Significant Critical Periods

Topic	AOI	Comparison	Speech Prior to and During Significant Critical Periods[a]
1. Describe something you can do well and feel confident about doing. (*Low-Low Demands)*			
	Nose	2	"(practice at, it's something I feel) pretty confident with, in terms of what I can do"
2. Share a time when you felt happy during the past week. (*Low-Low Demands)*			
	Mouth	1[b]	"(uh, earlier) this week, I was given, uh, a"
		2	"(given, uh, a big project to,) um, to do at work"
4. Describe an exciting trip or vacation that you went on as a child. (*High Cognitive Demands)*			
	Nose	1	"(When I was, uh, 9 years old,) um, my parents"
		2	"(my parents and my sister and I went) to, uh, Orlando"
		3	"(Orlando Florida, and) that was the first and only time I've ever been"
		4	"(and I liked going to Epcot and,) um, seeing all the sights down"
		6	"(Orlando and Universal Studios.) It was a great time, a lot of fun"
	Mouth	1	"(the first and only time I've ever been to Disney) World, and it was really ex(citing)"
7. Share a time when you were a child and had your feelings hurt. (*High-High Demands)*			
	Eyes	1	"(a hard time pronouncing things,) so that really hurt my feelings"
		2	"(that really hurt my feelings, and it made me) pretty embarrassed as well"
	Nose	1	"(a speech impediment. I had a) hard time saying my r's and my l's"
		3	"(afterwards, all the kids called me Elmer Fudd) because I had a hard time pronouncing things"
8. Describe a time when you remember feeling angry as a child. (*High-High Demands)*			
	Nose	1	"(upset at me for doing something. I don't remember) what it was but, um"
	Mouth	1[b]	"One time when I was younger, uh, my mom was"

Note. [a]Speech occurring in the two seconds prior to the onset of critical periods shown in parentheses. [b]Less than two seconds of preceding speech was available because the onset of the critical period occurred within the first two seconds of the video.

In contrast to the differences between groups for the eye region, significant critical periods for the Nose AOI appeared to primarily occur during periods of informative speech, as these periods included descriptive, factual information, such as specific details about the confederate's experiences. For example, during the same topic described for the eye region, a significant difference in viewing proportions was found for the nose region when the confederate explained why his classmates teased him ("hard time saying my r's and my l's"). Although this pattern appeared to fit with the significant critical periods identified across topics, this association was particularly salient for the confederate's response to the topic, "Describe an exciting trip or vacation that you went on as a child," which included five significant critical periods for the nose region (see Figure 13). During the confederate's response to this topic, he described a trip to Disney World, and thus, his response included more detailed information than his other responses (e.g., how old he was, who went on the trip, and what sites he saw).

Finally, significant critical periods for the mouth region appeared to coincide with periods in which the confederate's speech had more stops and starts, as well as a greater number of filled pauses (i.e., ums and uhs). Compared to other significant critical periods, the confederate's speech during these critical periods also tended to be less specific and less direct. For example, when describing a time when he was angry as a child, there was a significant difference in viewing proportions between groups when he stated, "One time when I was younger, uh, my mom was." Although this part of the confederate's response used a common colloquial phrase, it provided participants with little information about why he was angry (because his mother sold all his video games at a garage sale). Thus, differences in the proportion of participants fixating the mouth coincided with portions of the confederate's responses in which the content was vague because of filled pauses, syntax (e.g., dependent clauses), or colloquial phrasing.

7.5.1 Summary and discussion of results: Exploratory, frame-by-frame analyses

Differences in the proportions of participants viewing the Eyes, Nose, and Mouth AOIs were examined for eight stimuli that were viewed during listening portions of the interaction in order to explore whether any temporal-specific differences in gaze existed between groups. Consistent with visual inspection of viewing proportions across time, results from these analyses yielded relatively few instances in which the proportion of participants in the control group viewing an AOI differed from that of participants in the autism group. Thus in general, results from these analyses suggest that atypical patterns of visual attention were not ubiquitous among participants in the autism group, both with respect to gaze within and across narrative topics. Rather, findings from these analyses suggest that differences in gaze patterns were time-limited, rather than pervasive, as well as subtle when examined during real-time. Indeed, the viewing proportions of each group illustrate that there is significant variability among where individuals are looking, at least in terms of specific attention to facial features. As such, these analyses suggest that general statements about where individuals with ASD look (or do not look) when processing facial information, without regard to when they exhibit these gaze patterns, not only overstate the pervasiveness of atypical gaze among individuals with ASD, but also over simply the dynamic nature of gaze during face processing tasks. This is not to imply however, that group-level statistics are unimportant, but rather that the combination of both quantitative and qualitative data is necessary, particularly when attempting to characterize complex behaviors, such as visual attention during interactive contexts.

Indeed, in the current study, results from these frame-by-frame analyses provided additional support for the results obtained in the primarily analyses and helped identify contextual factors that may contribute to whether between-group differences in gaze are found. For example, the finding that from moment-to-moment, a similar proportion of participants in each group fixated the confederate's eyes is consistent with the group-level finding that participants in both groups spent a similar percentage of time fixating the eye region over the course of the interaction. Likewise, results from these analyses indicate that among facial features, differences in the proportion of participants viewing the nose yielded the greatest number of significant critical periods, thus mirroring earlier results that indicated that participants in the autism group spent less time fixating the nose region relative to participants in the control group.

Moreover, consideration of the confederate's speech just prior to the onset, as well as during significant critical periods revealed qualitative trends that may contribute to region-specific differences in the distribution of gaze between individuals with and without ASD. Although significant differences in viewing proportions for the eye region were only found for two critical periods, both of these periods corresponded with speech in which negative emotions were expressed. As such, this is consistent with research indicating that the eye region is the most informative facial feature for emotion recognition (e.g., Schyns et al., 2002). However, there is also evidence that TD individuals exhibit increased gaze to the eyes when viewing emotional, audiovisual face stimuli during an emotion recognition task, but not when viewing the same stimuli during a speech perception task (e.g., Buchan et al., 2007). This suggests that increased attention to the eye region during emotion recognition tasks is not exclusively driven by bottom-up differences in the visual information conveyed by the eyes of expressive compared to neutral faces, but rather the usefulness of this information for the task-at-hand. Thus, because the interaction task in the current study did not explicitly require participants to make affective judgments, it is possible that the relative increase in the number of participants in the control group viewing the confederate's eyes during these portions of the interaction served a function such as expressing empathy, rather than a perceptional function. Still, further research is required as group differences in viewing proportions for the eye region were only found during one out of the four topics examined that pertained to negative emotional experiences.

In contrast, significant differences between groups in viewing proportions for the nose region appeared to be associated with periods of informative or factual speech. More specifically, the confederate's speech appeared to be denser and more detailed during these significant critical periods. Because of these differences, it is possible that the confederate's speech during these parts of his responses was more cognitively demanding for participants to process and thus, that participants in the control group were more likely to fixate the confederate's nose as a way of facilitating speech processing. Although as described above, participants in the control group spent a greater percentage of time fixating the confederate's nose compared to those in the autism group, regardless of the type of stimulus viewed, their role during the interaction, or a topic's demands, these analyses suggests that this general difference in visual attention may be exacerbated when processing dense speech. More generally, this association between discourse density and fixations to the nose may clarify why in the primary analyses, participants spent a greater percentage of time fixating the confederate's nose when listening to his responses to topics that had high cognitive demands, as the majority of the significant critical periods were found during one of the two high cognitive topics examined.

Finally, significant differences in viewing proportions to the mouth tended to co-occur with periods of disfluent speech. Most notably the confederate's speech during these significant critical periods contained several filled pauses. Interestingly, research with TD individuals has shown that filled pauses, such as *uh* and *um*, facilitate speech perception for listeners in addition to serving a functional role for speakers (for review, see Corley, MacGregor, & Donaldson, 2007). In particular, there is evidence that listeners are more attentive to words that follow filled pauses, as indicated by faster word monitoring (Fox Tree, 2001), better memory recognition for speech (Corley et al., 2007), and more accurate predictions of future speech (Arnold, Kam, & Tanenhaus, 2007; Arnold, Tanenhaus, Altmann, & Fagnano, 2004). These results have been interpreted as indicating that filled pauses cue listeners to pay attention to discourse as the speech following these pauses will likely be unpredictable (e.g., Corley et al., 2007). Because fixations to the mouth region have been shown to improve the accuracy of speech perception in TD individuals (e.g., Paré et al., 2003), between-group differences in viewing proportions for the mouth may indicate that participants in the control group were more receptive to these cues and as a result, more likely to fixate the confederate's mouth to aid speech processing.

Although no research has directly examined how filled pauses during speech affect visual attention to faces, research on stuttering provides tentative support for this possibility. Specifically, there is evidence that among Western cultures, TD individuals tend to fixate the lower half of a speaker's face when listening to stuttered speech compared to fluent speech, as indicated by increased gaze to the nose (e.g., Bowers, Crawcour, Saltuklaroglu, & Kalinowski, 2010) or the mouth (e.g., Zhang & Kalinowski, 2012). Thus, it is possible that individuals with ASD are less likely to associate filled pauses with unpredictable speech or that they are less likely to direct fixations to the mouth as a compensatory way of processing unpredictable speech.

In summary, results from these analyses generally support those from the primary analyses regarding overall differences in visual attention between the autism group and the control group. However, they suggest that the observed, group-level differences in the gaze to the nose region, as well as more subtle differences in gaze to the eye and mouth regions (which were not identified in the primary analyses) may be related to nuanced, contextual factors during interactions. Thus, it is possible that individuals with ASD are less sensitive to certain nuanced aspects of speech, which are likely learned through repeated social experiences, or that they are less likely to strategically shift their gaze in response to these cues. Still, it is necessary to reiterate that these analyses identified qualitative trends between the content of the confederate's speech and group differences in viewing proportions, and thus, more systematic research is required to evaluate how these contextual factors affect gaze in individuals with and without ASD.

Furthermore, several caveats should be noted. Because of the exploratory nature of these analyses, a conservative approach was taken to the identification of critical periods. Even still, 54 critical periods were identified across the eight stimuli analyzed. Given the amount of data that did not meet the criteria used to identify significant critical periods, contextual factors were not examined for nonsignificant periods of the confederate's responses even though this would have provided a useful comparison for these analyses. Although identifying contextual factors associated with instances in which viewing proportions were similar for the two groups was beyond the scope of the current study, such comparisons will be important for validating the qualitative trends identified in the current study and for establishing a more balanced model of gaze in individuals with ASD.

8.0 GENERAL DISCUSSION

The primary aims of current study were to examine face processing, as indexed by eye movement data, in adults with ASD during an interactive context and to explore the effects of exogenous factors (e.g., task demands) and endogenous factors (e.g., social anxiety) on patterns of visual attention. More generally, the current study sought to address limitations within the extant literature on face processing in ASD by studying visual attention to faces during a more ecological-valid context and by systematically exploring top-down factors that may contribute to the typicality (or atypicality) of visual attention to faces in individuals with ASD. Although the use of eye tracking has advanced our understanding of face processing in typical and atypical development, the bulk of research has examined visual attention to static faces and as result, concerns have been raised by both TD and autism researchers regarding the extent to which findings from these studies can be generalized to how individuals attend to faces in real life (e.g., Risko et al., 2012; Speer et al., 2007). Within the face processing research on ASD, these concerns are particularly significant as it has been suggested that differences in the perceptual processing demands required for static faces compared to more realistic, dynamic faces may be responsible for the inconsistent results reported across studies.

In recognition of these limitations, there has been an increase in research using dynamic, audiovisual stimuli to assess visual attention to faces in individuals with ASD (e.g., Jones et al., 2008; Nakano et al., 2010; Speer et al., 2007). In addition, a handful of studies have examined face-directed gaze during live interactions (Doherty-Sneddon et al., 2012; Doherty-Sneddon et al., 2013; García-Pérez et al., 2007; Nadig et al., 2010; Riby et al., 2012; Tantam et al., 1993). However, both of these types of studies have limitations in terms of understanding how individuals with ASD process faces in naturalistic settings. Specifically, results from the former type of study have provided information on region-specific gaze patterns, but still do not account for the interactive context in which faces are typically encountered, whereas, the latter type of study has described general, patterns of face-directed gaze during interactive contexts, but does not provide information on how individuals attended to specific facial regions. In addition, only a few of these studies systematically examined how stimulus or task demands may influence patterns of visual attention to faces in individuals with ASD (e.g., Speer et al., 2007). As a result, these studies provide primarily indirect evidence that atypical visual attention in ASD is related to stimulus complexity and they do little to clarify what other top-down factors may be influential.

Thus, the current study is significant in that it is first to examine patterns of visual attention to specific facial regions in adults with and without ASD during an interactive context. In addition, this study is unique in that it systematically examined the effects of stimulus complexity, conversational role, and task demands on visual attention to face stimuli. To accomplish these objectives, a significant departure from the traditional methodologies used to examine visual attention to faces was required. Specifically, the current study assessed patterns of visual attention during an acquaintance task in which participants thought they were interacting with another participant over a video-feed; however, pre-recorded videos of a confederate engaging in the task were shown to participants to simulate a live, video-mediated interaction. The novel methodology employed during this study was critical for overcoming some of the limitations of prior research noted above, and thus, it represents an innovative way of examining how individuals with and without ASD process visual information when viewing faces during more naturalistic contexts. Most notably, the use of pre-recorded video stimuli made it possible to examine specific gaze patterns by reducing the number of stimuli that needed to be analyzed since all participants viewed the same videos. Furthermore, the use of pre-recorded videos ensured that the confederate's behavior, as well as participants' overall experience during the interaction was similar across all individuals and thus, that differences in gaze could be attributed to either group membership or the experimental manipulations. Although this method necessitated that a highly-structured and controlled task be used in order to disguise the pre-recorded nature of stimuli, results from this study show that the pre-recorded videos effectively created an illusion of a reciprocal, video-mediated interaction, as only two participants reported doubting that the interaction was live.

In addition to demonstrating a novel paradigm for research on face processing, several important findings emerged from the current study. First, the current study adds to the TD literature indicating that patterns of visual attention to faces differ depending on the type of stimulus viewed and thus, that findings pertaining to how individuals attend to static faces cannot be directly extended to how individuals attend to dynamic faces during interactive contexts (Risko et al., 2012). Furthermore, results from this study suggest that the social context in which dynamic faces are viewed may have a unique effect on patterns of visual attention, beyond the effects of dynamic motion and audiovisual information. For instance, individuals regardless of diagnostic group spent significantly less time fixating the confederate's eyes, nose, and face when viewing dynamic stimuli during the interaction phase compared to when viewing a static image of the confederate during the screening phase. Similarly, individuals in the both the control group and the autism group exhibited shorter fixation durations when viewing dynamic stimuli during the responding portions of the interaction phase compared to when viewing a static stimulus prior to the interaction. As such, visual attention in both of these examples decreased rather than increased when individuals viewed more visually demanding stimuli. Because stimulus complexity alone is unable to account for these findings, it seems likely that the social context in which dynamic stimuli were viewed influenced how individuals attended to faces.

At present, only a few studies with TD individuals have explicitly examined how social presence affects visual attention to faces (e.g., Foulsham et al., 2011; Laidlaw et al., 2011). Specifically, these studies compared visual attention to dynamic faces during situations in which social interactions were either possible or not possible and found that social presence attenuated the degree to which TD individuals attended to faces (for review, see Risko et al., 2012). As such, findings from these studies parallel the observed reduction in gaze between the interaction phase and the screening phase of the current study. Although the current study did not control for differences in stimulus complexity between these two phases, this similar pattern of results is still notable given that if visual attention was confounded by stimulus complexity, the increased complexity of interaction phase stimuli would have presumably weakened the association between social presence and gaze, not enhanced it. Thus, while limitations in the current study's design make it impossible to ascertain the degree to which visual attention was attenuated across stimulus types, these results provide general evidence that social presence affected how individuals with and without ASD attended to faces.

Additional, though somewhat circumstantial evidence for the effects of social presence on visual attention to faces in the current study is provided by contrasting the percentage of time individuals spent fixating dynamic, audiovisual stimuli during the listening portions of this study to the percentages reported by prior research in which similar stimuli were passively viewed. For example, individuals with and without ASD spent approximately 10% of the time looking at the confederate's eyes while listening to pre-recorded videos of him speaking during the current study, thus representing a significant reduction in visual attention compared to findings from other studies using dynamic, audiovisual stimuli (e.g., Buchan et al., 2007; Henderson et al., 2005; Nakano et al., 2010). In comparison, a study by Buchan and colleagues (2007) using stimuli similar to those used in the current study reported that TD adults spent approximately 25% of the time fixating the eye region of an actor during an audiovisual speech task. As in the listening portions of the current study, stimuli depicted a single actor saying sentences with different emotional valences and no affective judgments were required during the task. Thus, although the overall design of the current study differed in notable ways from the study by Buchan and colleagues (2007), none of these differences can account for the relative decrease in the percentage of eye gaze exhibited by TD adults in the current study when viewing dynamic, audiovisual stimuli, with the exception of participants' belief that the videos viewed were live rather than pre-recorded. These differences in gaze across studies, together with the unexpected differences between dynamic and static stimuli noted above, suggest that the social context in which faces are viewed has a meaningful effect on visual attention.

In addition to demonstrating the general importance of using ecologically-valid stimuli to examine associations between patterns of visual attention and face processing, results from this study show that more realistic stimuli, such as dynamic faces viewed within a social context, are critical for clarifying how gaze may contribute to face processing impairments in ASD. Specifically, the current study provides additional evidence that disparities between how individuals with and without ASD attend to faces are moderated by the type of stimulus viewed and the viewing context (e.g., Doherty-Sneddon et al., 2012; Speer et al., 2007). With the exception of gaze to the nose region, which has rarely been examined by prior research, adults in the autism group exhibited typical gaze patterns when viewing a simple, static stimulus, but reduced gaze when viewing more complex, dynamic stimuli during the listening portions of the interaction. Still, results from this study indicate that the nature of this relationship is complex, as gaze patterns were similar between the two groups when viewing silent, dynamic stimuli during the responding portions of the interaction, again with the exception of visual attention to the nose. Furthermore, results from this study differed from those reported by the only other study to directly contrast gaze pattern for static and dynamic stimuli, which found between-group differences in visual attention when participants viewed dynamic stimuli depicting multiple individuals but not when participants viewed dynamic stimuli depicting a single individual (Speer et al., 2007). These differences seem to indicate that although both the type of stimulus viewed and the context in which stimuli are viewed can affect the extent to which individuals with ASD exhibit typical gaze patterns, the interplay between these variables is also important. Moreover, preliminary results from this study suggest that this complex association may differ between subgroups of individuals with ASD, thus further complicating explanations concerning how gaze affects face processing in individuals with ASD and how atypical gaze patterns in this clinical population arise.

However more generally, results from the current study are significant in that they suggest that the patterns of visual attention exhibited by individuals with ASD are not grossly atypical, at least when assessed during an interactive, but highly structured task. Across all analyses, relatively few differences in visual attention were found between the control group and the autism group, even when temporal viewing patterns were examined in the frame-by-frame analyses. Furthermore, when differences in visual attention were found between groups, they were rarely qualified by significant interactions with other independent variables, indicating that in general, adults in both groups were similarly influenced by the type of stimulus viewed, their role during the interaction, and topic demands. For example, individuals with and without ASD demonstrated the same pattern of visual attention across stimulus types with regard to the percentage of time spent fixating the confederate's eyes, nose, and face (static > dynamic-listening > dynamic-responding) and with regard to the percentage of time spent fixating the confederate's mouth (dynamic-listening > static > dynamic-responding). Likewise, when eye movements from the entire interaction were analyzed, both groups tended to exhibit longer fixation durations, shorter distances between fixations, and increased percentages of time fixating regions of the confederate's face when listening compared to responding.

Although there were two instances in which the effects of conversational role on visual attention were moderated by group membership, in both of these cases, the observed effects in the autism group differed in magnitude but not in direction from those in the control group (e.g., the autism group exhibited a greater decrease in visual attention to the confederate's face and a smaller increase in scanpath distances when responding compared to listening during the interaction). Thus, gaze patterns of individuals with and without ASD appear to be similarly affected by one's role and by the emotional valence and recency of narrative topics, at least during structured, video-mediated interactions. These findings are significant as they suggest that striking differences between adults with ASD and TD adults do not exist in terms of their overall distribution of attention within faces or their ability to shift how they allocate attention as a task's demands change, even when faces are viewed within an interactive context. Moreover, results from this study add to the growing literature indicating that individuals with ASD exhibit typical shifts in face-directed gaze when listening compared speaking (Doherty-Sneddon et al., 2012; García-Pérez et al., 2007; Nadig et al., 2010; Riby et al., 2012), as well as when a task's cognitive demands are increased (Doherty-Sneddon et al., 2012; Riby et al., 2012).

However, additional support for social demands moderating visual attention in individuals with ASD is lacking within the extant literature, as results from the current study differ from those reported by the only other autism study that has examined the effects of social demands on gaze during an interactive context (Doherty-Sneddon et al., 2013). Specifically, Doherty-Sneddon et al. (2013) found that familiarity did not moderate face-directed gaze in adolescents with ASD, whereas TD adolescents exhibited an increase in face-directed gaze when interacting with a familiar adult compared to an unfamiliar adult. Given differences between how social demands were manipulated in this previous study compared to the current study, it is not altogether surprising that these two studies yielded different results. Rather, these conflicting results illustrate the need for caution in generalizing the results from the current study to other types of cognitive or social demands. For example, even though the familiarity of one's partner and the intimacy of narrative topics both influence the degree to which social discomfort is experienced during interactions and the extent to which gaze is averted by TD individuals, these commonalities do not necessitate that these convergent gaze behaviors developed in a unified or similar way. Thus, despite evidence indicating that visual attention is moderated by certain types of top-down demands in individuals with ASD (e.g., conversational role), further research is needed to examine how other top-down factors influence visual attention in this clinical population.

Because limited research has examined how top-down factors affect patterns of visual attention to faces specifically during interactive contexts, qualitative analyses of temporal-specific differences in viewing patterns between individuals with and with ASD during interactions, such as the frame-by-frame analyses conducted in the current study, will likely be critical for identifying top-down factors to be examined by future research. In the current study, analysis of significant differences in viewing proportions between groups and the contextual factors associated with these differences yielded three trends that merit further study, as they may help identify situations in which individuals with ASD are more likely to exhibit atypical attention to faces. Specifically, these analyses indicated that the expression of negative affect and the co-occurrence of speech that is either dense in information or disfluent may differentially affect how individuals with ASD, relative to TD individuals, attend to their partner's face. Although research examining how top-down factors affect patterns of visual attention to faces during interactions can be challenging to both design and analyze, this type of research is important for understanding how face processing impairments, as well as other social-communicative deficits arise in ASD. Furthermore, identifying contexts in which visual attention to faces is either spared or less disrupted in individuals with ASD may help improve the effectiveness of intervention programing by promoting errorless learning and by increasing the extent to which skills are generalized to naturalistic environments.

Despite these notable similarities in the patterns of visual attention exhibited by individuals with and without ASD, significant differences in the degree to which individuals with ASD fixated specific facial regions were also found. Most importantly, the current study provides robust evidence that visual attention to the nose region, rather than to the eye or mouth regions, is important for distinguishing adults with ASD from TD adults. Interestingly, adults with ASD spent significantly less time fixating the confederate's nose compared to TD adults, regardless of stimulus type, participant's role, or topic demands, whereas, no differences were found between groups in the percentage of time spent fixating the confederate's eyes or mouth. Furthermore, these mean-level differences in visual attention were upheld even when time-sensitive differences in viewing proportions were examined for the two groups. These findings are significant as they challenge predominant theories regarding how visual attention contributes to face processing deficits in individuals with ASD. However, even though the observed null effects for the eye and mouth regions were unexpected, results from this study are also not unique, as neither decreased visual attention to the eye region nor increased visual attention to the mouth region has been consistently reported in the autism literature (e.g., Bal et al., 2010; Falck-Ytter et al., 2010).

In contrast, the current study's findings regarding gaze to the nose region are particularly interesting as only two of the studies reviewed above examined fixations to the nose region, with one reporting a difference between groups in attention to the nose (Pelphrey et al., 2002) and the other not (Chawarska & Shic, 2009). Because of the novel method used in the current study and the uniqueness of this finding, at least with regard to face processing impairments in ASD, the significance of these results is unclear. However, given the TD literature indicating that the nose region represents an ideal vantage point for processing facial information, reduced attention to the nose may help explain face processing impairments in ASD (Peterson & Eckstein, 2012). Furthermore, because fixating the nose is thought to allow for more efficient processing of static faces, it is likely that this strategy is even more critical when viewing temporally-constrained information from dynamic or dynamic-interactive faces, as there is a greater risk of missing important information during saccades. Thus, it is possible that decreased visual attention to the nose region of faces could negatively affect social-communicative skills in individuals with ASD in two ways. First, by increasing the demands associated with visual processing of faces during interactions and second, by creating greater disruption in the stream of visual information available to be processed. As with speech processing during a phone call with bad wireless reception, this could lead to fragmenting visual information and thus poorer processing of nonverbal cues.

Should results from the current study be replicated, it will be important to determine whether the pattern of typical gaze to the eyes and mouth but reduced gaze to the nose is unique to interactive contexts or whether this pattern is also apparent during other contexts in which individuals with ASD view faces. Although this pattern of visual attention did not differ depending on stimulus type, the context in which individuals viewed the static stimulus in the current study was unusual as they were told that it depicted an individual who could be their partner during the interaction task. As a result, it is possible that this instruction primed individuals to process the static image of the confederate's face in a way that was similar to how faces are processed during interactive contexts. However, because the extant research demonstrating the importance of the fixations to the nose have exclusively used paradigms in which static or dynamic stimuli are passively viewed, this possibility seems unlikely. As a result, findings from the current study, as well as those from research with TD individuals draw into question conclusions drawn by prior autism research examining visual attention to faces. In particular, it is unclear whether differences in gaze to the nose region existed but were not examined by research in which gaze was reported to be typical in individuals with ASD (e.g., Kirchner et al., 2011; Sterling et al., 2008). Nor is it clear whether reported differences in visual attention to the eye region should actually be attributed to the nose region, at least among studies that included portions of the nose when defining eye regions for analysis (e.g., Bal et al., 2010; Jones et al., 2008).

Because the importance of fixations to the nose has only been examined during face processing in adults, it will be critical for research to explore how this strategy develops in both TD individuals and individuals with ASD. However, recent research indicates that experience, at least in part, contributes to the development of fixation strategies and that fixation strategies remain malleable in TD adults (Peterson & Eckstein, 2013b). Specifically, a study by Peterson and Eckstein (2013b) using modified faces found that TD adults flexibly shifted from preferentially fixating the nose to fixating a new facial location when the former strategy was no longer optimal during a task. Though the extent to which individuals spontaneously shifted was variable, explicit instruction through gaze cuing was able to help individuals, who otherwise exhibited inflexible patterns of visual attention, adopt the new optimal fixation strategy. As result, if findings from the current study are replicated, it is possible that individuals with ASD may similarly benefit from interventions that use gaze cuing to promote more efficient face processing.

In addition, it will be important for future research to consider whether fixations to the nose region serve any additional functions when faces are encountered during interactions, beyond maximizing the discriminability of visual information within the fovea. For example, fixating the nose region of faces could also be associated with the expression of nonaggressive or empathic eye contact during social contexts, as research has shown that TD individuals perceive general gaze to an individual's face as eye contact (Gamer & Hecht, 2007; Kleinke, 1986; Lord & Haith, 1974). Because fixations to the eye region are not necessary for establishing eye contact, the unexpected association in the current study between social demands and fixations to the nose rather than the eye region provides tentative support for fixations to the nose serving a social function. Thus while general, face-directed gaze is perceived as eye contact, it is possible that the location and durations of fixations contribute to subtleties in how gaze is experienced both in terms of the gazer and the observer. In addition, these findings suggest that the direction to “make eye contact” or “look others in the eye” may not be particularly helpful advice. Given the colloquial definition of eye contact, as “a situation in which two people are looking directly into each other's eyes,” (*Merriam-Webster's online dictionary*, n.d.) and the tendency for individuals with ASD to take expressions literally, these directions could cause individuals with ASD to try to exhibit prolonged fixations to the eye region. Such a strategy would not only be detrimental from a face processing perspective, but could also lead to the development of an aversive association with eye gaze if prolonged fixations to the eyes are experienced as staring.

It is also possible that fixations to the nose region may facilitate configural processing during interactions. Given the degree to which configural processing is thought to contribute to typical and atypical face processing, surprisingly little research has examined whether information processing strategies are associated with unique patterns of visual attention (Bombari et al., 2009; Schwarzer et al., 2005). In the current study, reduced scanpath distances and shorter average fixation durations were predicted for the autism group based on research suggesting that featural processing may be characterized by a greater proportion of within feature fixations and less efficient processing. Although only the former prediction was supported, these predictions were based on research using static stimuli, and while speculative, it seems plausible that different fixations strategies may facilitate configural processing when viewing dynamic faces. In these situations, it is possible that fixating the nose may represent a better way of processing configural information. Specifically, because configural information conveyed by faces in these contexts is also dynamic, quick scanning across features may be detrimental rather than facilitative, leading to more configural information being missed during saccades. If so, spending a greater percentage of time fixating the nose and longer fixation durations to this region may be better indicators of configural processing when viewing dynamic faces.

Although further research is needed to directly examine the relationship between fixating the nose and configural processing, the limited TD research examining gaze patterns in relation to information processing strategies provides some support for this possibility. Specifically, Bombari and colleagues (2009) examined gaze patterns during a same-different task that involved matching intact, test faces to previously cued faces. Results indicated that TD adults spent a greater percentage of time fixating the nose region of test faces after viewing intact, unmodified face cues compared to modified face cues that promoted either configural processing (i.e., blurred faces) or featural processing (i.e., scrambled faces). Though this finding was not predicted, it was suggested that increased gaze to the nose region may reflect a holistic processing approach, which Bombari and colleagues defined as the simultaneous processing of broad facial regions. Currently there is no consensus among researchers regarding whether configural processing and holistic processing are distinct or analogous constructs, still at a minimum these two processes are generally considered to be related (Piepers & Robbins, 2012). Thus, future research characterizing differences in gaze to the nose region may help integrate findings from research on information processing strategies with those from research on visual attention and therefore, may help to develop a more robust model of face processing in ASD.

Finally, results from both the analyses related to individual differences and those related to temporal-specific viewing proportions are significant as they illustrate the heterogeneity that exists in terms of how individuals with and without ASD allocate their attention while viewing faces. Although none of the individual characteristics examined in the current study, with the exception of social anxiety, were correlated with differences in visual attention, this study adds to the literature indicating that meaningful subgroups exist among individuals with ASD (e.g., Rice et al., 2012). Moreover, results from the current study provide preliminary evidence that prior participation in a social skills intervention may be associated with more typical gaze during interactions. As described above, further research is needed to examine this association between social skills participation and visual attention given the small sample sizes for the subgroups examined in the current study and the correlational nature of these analyses. However, if this finding is replicated, it will be important for future research to explore what critical factors mediate this association.

8.1 CLINICAL SIGNIFICANCE

As indicated above, results from current study are clinically significant for several reasons. Although these reasons are highlighted within the general discussion, a summary is provided here. First, the current study demonstrated a novel paradigm that can be used to examine how individuals with ASD process faces in a more naturalistic situation. Examining social phenomenon, such as face processing, in ecologically-valid contexts is critical for accurately describing the autism phenotype, conceptualizing how impairments associated with this disorder arise, and guiding the development of interventions. Thus beyond the clinical significance of specific results, this study paves the way for future research on visual attention during interactive contexts to be conducted with individuals with ASD.

Second, results from this study reveal contexts in which face processing demands may be reduced (e.g., viewing static faces) or increased (e.g., listening during a dyadic interaction) for individuals with ASD. As a result, findings from this study may help inform interventions by guiding how programs designed to teach skills that involve face processing are systematically structured, thereby promoting errorless learning. For example, because face-directed gaze was most atypical during listening portions of the interaction, an intervention program targeting identification of emotions during interactions may first need to systematically increase the amount of face-directed gaze when viewing an individual speaking, without any additional demands (e.g., not requiring conversation, assessing speech comprehension, or making affective judgments). After acquiring this basic skill, individuals could then be taught to maintain face-directed gaze while monitoring the content of an individual's speech and so on, such that additional demands are added once simpler component skills are acquired.

Finally, results from the current study suggest that the instruction to "look others in the eyes," is arbitrary and may be detrimental for face processing. Adults in the current study, regardless of diagnosis, spent approximately 10% of the time fixating the eyes when listening and 5% of the time when speaking, and thus, this direction may encourage individuals with ASD to adopt or to attempt to adopt an atypical pattern of gaze during interactions. Although it is unclear whether increased gaze to the eye region engenders any social advantages or disadvantages, there is evidence that fixating the nose is more functional for face processing. Thus, individuals with ASD may benefit from being directed to look at a conversational partner's face rather than make eye contact during interactions. In addition, should decreased attention to the nose region be documented by future research, interventions that use gaze cuing to promote fixations to the nose region should be considered for targeting face processing impairments in individuals with ASD.

8.2 LIMITATIONS AND FUTURE DIRECTIONS

Although the current study represents a significant step toward understanding how individuals with ASD attend to faces during day-to-day interactions, several limitations must be noted. First, this study examined visual attention in high-functioning adults with ASD, and thus, it is unclear to what extent these findings may differ in younger individuals or individuals with intellectual disabilities. Second, this study examined visual attention during a simulated and highly structured interaction which individuals believed was taking place via video-mediated communication. Even though results from the preliminary analyses indicate that the majority of participants were convinced the interaction was live, neither pre-recorded videos nor live, video-mediated interactions are capable of replicating the verbal and nonverbal synchrony that typically characterizes face-to-face interactions. The structured nature of the task in the current study was in part designed to minimize asynchronies during the interaction, still it is possible that viewing patterns may differ during face-to-face interactions or that there may be greater cohesion among where individuals are looking at a specific time. Likewise the provision of predefined times to speak and listen during the interaction, as well as scripted topics may have influenced the findings from the current study. The chained nature of events during the interaction task made it possible to isolate the effects of participant's role and topic demands. However, it is possible that individuals with ASD may demonstrate more atypical patterns of visual attention to faces during fluid interactions in which turn-taking is not prescribed. Because one must independently navigate when to speak versus listen and because one is often required to play a more active role in order to sustain the interaction (e.g., by asking follow-up questions based on a partner's responses), task demands are likely greater during less structured interactions. Thus, results from this study likely represent a conservative estimate of the degree to which high-functioning individuals with ASD exhibit atypical visual attention during day-to-day, dyadic interactions.

In addition to these limitations, two additional caveats are necessary regarding the significance of results in which typical gaze patterns were found in the autism group. First, because no performance measure was included to assess the accuracy of participants' face and speech processing following the interaction, it is possible that differences existed between the autism group and the control group, despite similarities in gaze. Second, given the subtle nature of differences in gaze, more fine grain analyses examining how gaze is integrated with speech may reveal important differences between groups, particularly as research has shown that interactions with individuals with ASD may be perceived differently by observers even when their gaze is similar to that exhibited by individuals without ASD (e.g., Nadig et al., 2010). Furthermore, indexes of visual attention were not correlated with autism symptoms and thus, typical patterns of visual attention to faces should not be interpreted as indicating intact perceptual skills or less social-communicative difficulties.

As a result, further research is required to replicate and clarify findings from the current study. Given the heterogeneity within individuals with ASD and the potential for developmental changes in gaze patterns, research examining visual attention to dynamic-interactive faces in samples that include individuals with ASD across a broader age span and across a range of cognitive abilities is needed. In addition, while highly-controlled studies on face processing in

ASD are important, research that examines how gaze patterns during these controlled contexts compares to that during naturalistic settings is critical for developing ecologically-valid theories and effective interventions (Risko et al., 2012). As a result, research examining the effects of different types of cognitive and social demands, as well as the effects of different types of interaction formats on visual attention to faces is needed. In turn, results from studies using more ecologically-valid designs will help inform future, basic research.

In particular, it will be important for future research to examine gaze during less structured, interactions in which listening and speaking roles are flexibly interchanged. In these situations, gaze serves additional social-communicative functions, such as cuing when an individual is finished speaking, and thus, these situations may result in different patterns of visual attention. Because the current study was the first to examine region-specific gaze patterns during an interactive context, pre-recorded stimuli and a structured task were beneficial as these controls made it possible to attribute any differences in gaze to the task demands. However, the current study's method can easily be altered to examine how patterns of visual attention may differ, both in individuals with and without ASD, when turns during an interaction are not prescribed. For instance, it would be interesting to compare these results to a study using the same method, with the exception of using live videos of a confederate and having the interaction be self-paced, such that the members of the dyad are responsible for the turn-taking organization. For example, participants could be given a list of topics and instructed to discuss each with their partner.

8.3 CONCLUSIONS

In summary, the current study demonstrated that a novel method using pre-recorded videos to simulate a structured, video-mediated interaction can be used to better understand how adults with and without ASD process facial information during interactive contexts. Results from this study also show that using ecologically-valid designs is important for understanding the relationship between face processing and eye movements, as both patterns of visual attention and the typicality of gaze exhibited by the autism group, relative to that exhibited by the control group, differed depending on the type of stimulus viewed. In addition, this study demonstrated that top-down factors generally moderate the percentage of time spent fixating facial regions, the average duration of fixations, and scanpath distances in individuals with ASD in a similar way to that of TD individuals. However, this study also revealed instances in which gaze differed between groups. As such, differences in visual attention were most robust when gaze was assessed for the nose region and when gaze was examined during listening portions of the interaction. Finally, the current study identified participant characteristics (i.e., social anxiety symptoms and social skills participation) and contextual factors (i.e., emotional, dense, or disfluent speech) which were associated with variability across individuals and across groups, respectively. Still, while this study represents an important first step with regard to understanding how individuals with ASD process faces during interactions, extensive research is needed to examine how these findings differ depending on sample characteristics and to explore how different facets associated with interactive contexts influence patterns of visual attention, including the typicality of these patterns.

APPENDIX A

POST-INTERACTION QUESTIONNAIRE

Please indicate how strongly you agree or disagree with the following statements, using the following scale.

1 — 5

Strongly — Strongly

1. My partner seemed to understand my concerns. _____
2. Compared to face-to-face conversations, it was easier for me to listen to someone else talk about their feelings. * _____
3. My partner seemed uncaring. _____
4. I admire my partner. _____
5. My partner made me feel comfortable talking about feelings. _____
6. My partner listened carefully to me. _____
7. Compared to face-to-face conversations, it was easier for me to talk about my experiences.* _____
8. I really think I got to know this person well. _____
9. Compared to face-to-face conversations, it was easier for me to talk about my feelings.* _____
10. I believe my partner and I "hit it off." _____
11. It would be easy for me to be friends with my partner. _____
12. I talked a lot about my personal experiences. _____
13. My partner was sensitive to my feelings. _____
14. My partner made me feel valued as a person. _____
15. I felt comfortable talking to my partner. _____
16. My partner did not take my concerns seriously. _____
17. I like my partner. _____
18. My partner talked a lot about his personal experiences. _____
19. Aside from talking to a stranger in a lab setting, this interaction did not seem unusual. _____
20. My partner talked a lot about his deepest feelings. _____
21. I talked a lot about my deepest feelings. _____

Note. Questions followed by *s indicate questions that were not adapted from Gore (2009).

Figure A1. Post-Interaction Questionnaire

APPENDIX B

MODIFIED NARRATIVE TOPICS FOR THE “GET ACQUAINTED” EXERCISE

	Unmodified Topics	Modified Topics	
	The Ungame	**Recent Memory (Low Cognitive)**	**Remote Memory (HighCognitive)**
Neutral/Positive Valence (Low Social)	1. What is one of your hobbies?	What did you do last week for fun?	When you were a child, what did you like to do for fun?
	2. What is something you can do well?	What is something you can do well?	When you were a child, what was something that you could do well?
	3. Tell about the neatest birthday present you ever received.	Tell about your favorite present that you received for your last birthday.	Tell about the best birthday present you received when you were a child.
	4. Tell about a time when you felt proud of yourself.	Tell about a time in the last year when you felt proud of yourself.	Tell about a time when you were a child, and you felt proud of yourself.
	5. Share one of the happiest days of your life.	Share your happiest experience during the past week.	Share one of your happiest experiences as a child.
	6. Describe your favorite trip/vacation.	Describe your favorite trip or vacation that you have been on in the last year.	Describe your favorite trip or vacation that you went on as a child.
Negative Valence (High Social)	7. Do you ever feel lonely? When?	Describe a recent time when you felt lonely.	Describe a time when you remember feeling lonely as a child.
	8. Share something you fear.	Describe a time when you were nervous or afraid in the last year.	Describe a time when you felt nervous or afraid as a child.
	9. When do you get angry?	Describe a time in the last year when you got angry.	Describe a time when you remember feeling angry as a child.
	10. What really annoys you?	Describe at time in the last week when you were annoyed or irritated.	Describe a time when you remember feeling annoyed or irritated as a child.
	11. Share a time when you had hurt feelings.	Share a time during the last year when you had hurt feelings.	Share a time when you were a child and had hurt feelings.
	12. Share a time in your life when you were embarrassed.	Share a time when you were recently embarrassed.	Share a time when you were embarrassed as a child.

Figure B1. Modified narrative topics. Low-low topics are indicated by diagonally striped shading; topics with high cognitive demands are indicated by solid shading; topics with high social demands are indicated by no shading; and high-high topics are indicated by vertically striped shading.

APPENDIX C

REASONS GIVEN FOR DISAGREEING WITH THE SUSPICION CHECK

Table C1. Reasons Given by Participants for Disagreeing with the Suspicion Check

Group	Reason(s)
Control	• "There wasn't any talking back" (i.e., couldn't respond to what partner said)
Control	• "Not a face to face interaction, no back and forth"
Control	• "Natural pacing was off" because of delay ***After the debrief, participant noted that he was suspicious about the interaction being live*
Autism	• Unusual because of the way the task was structured
Autism	• "Didn't use each other's names," had to call partner Participant 2
Autism	• Childhood and recent questions weren't in an order • Couldn't respond or react to each other's responses • *Not "entirely sure" talking to a "real person"*
Autism	• Wasn't able to ask questions ***After the debrief, participant said that he did not suspect the "interaction was fake"*
Autism	• Didn't seem like a conversation, "more just like answering questions"
Autism	• Interaction seemed "stilted" • There wasn't "much reciprocity"
Autism	• Because the topics were scripted, and "couldn't freely choose what to discuss"
Autism	• Partner's "gestures were different" ***After debrief, said participant said that he "thought the interaction was real"*
Autism	• NA (participant's response was not recorded)

APPENDIX D

CORRELATIONS BETWEEN POST-INTERACTION QUESTIONNAIRE RATINGS AND INDEXES OF VISUAL ATTENTION

Table D1. Correlations between Post-Interaction Questionnaire Ratings and Indexes of Visual Attention Depending on Participant's Role for All Participants (*n*=38)

		Suspicion Check		Responsivity		Likability	
Variable		*r*	Unadj. *p*	*r*	Unadj. *p*	*r*	Unadj. *p*
%Face							
	Responding	.00	.986	17	.300	22	.193
	Listening	.10	.539	09	.596	07	.664
Avg. Duration	**Fixation**						
	Responding	-.23	.161	.15	.359	.12	.462
	Listening	-.04	.834	.08	.617	.20	.237
Avg. Distance	**Scanpath**						
	Responding	.08	.636	.07	.686	.21	.195
	Listening	-.07	.664	.05	.746	.14	.392

Note. Indexes of visual attention calculated for topics that had low cognitive demands and low social demands (i.e., low-low topics).
Unadj. *p*= *p* value prior to FDR correction for multiple comparisons.

APPENDIX E

REVISED DESCRIPTIVE AND INFERENTIAL STATISTICS FOR THE EFFECTS OF GROUP AND STIMULUS TYPE ON THE PERCENTAGE OF TIME SPENT FIXATING AOIS AFTER CONTROLLING FOR VIEWING DURATION

Table E1. Effects of Group and Stimulus Type on the Percentage of Time Spent Fixating AOIs after Controlling for Viewing Duration

		STIM						ANOVA Results					
		Static		D-List		D-Resp		STIM		GRP		STIM X GRP	
AOI	GRP	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	Sig.	*F*	Sig.	*F*	Sig.
Eyes	CON	22.13	33.80	7.45	10.76	4.53	6.52	20.84	***	1.20	ns	1.97	ns
	AUT	35.91	27.46	6.20	8.05	4.71	7.74						
Nose	CON	29.46	29.21	18.97	15.42	5.05	6.63	14.49	***	6.11	*	1.43	ns
	AUT	16.44	16.24	9.09	10.87	3.41	5.36						
Mouth	CON	11.75	13.13	27.94	19.54	4.22	5.95	26.35	***	1.40	ns	1.94	ns
	AUT	9.28	11.46	18.58	17.31	4.99	7.57						
Face	CON	85.68	12.97	78.26	13.04	20.81	12.17	157.95	***	6.40	*	5.21	**
	AUT	80.43	17.89	54.17	26.83	18.74	21.99						

Note. STIM=Stimulus Type; GRP=Group; CON=Control Group; AUT=Autism Group; D-List=Dynamic Listening Stimulus; D-Resp=Dynamic Responding Stimulus; Sig.=Significance.

*$p<.05$. **$p<.01$. ***$p<.001$.

APPENDIX F

PERCENTAGE OF TIME SPENT FIXATING AOIS

Table F1. Percentage of Time Spent Fixating AOIs for the Control Group (*n*=19) and the Autism Group (*n*=19)

Participant's Role	Topic	Group	Eyes *M*	Eyes *SD*	Nose *M*	Nose *SD*	Mouth *M*	Mouth *SD*	Face *M*	Face *SD*
Responding	Low-Low	Control	4.91	5.64	6.86	5.98	4.17	4.81	26.12	14.11
		Autism	4.70	7.74	3.70	5.49	3.55	4.75	20.19	19.01
	High Cognitive	Control	4.12	4.49	9.12	9.88	4.69	7.79	29.40	17.68
		Autism	4.83	7.88	4.77	4.07	4.82	6.73	24.60	19.63
	High Social	Control	4.15	4.34	8.29	9.70	5.17	5.38	29.70	15.67
		Autism	5.39	8.36	3.63	6.71	4.97	6.23	21.80	21.09
	High-High	Control	4.18	5.22	4.49	4.48	3.69	3.98	22.03	12.13
		Autism	4.69	8.15	2.84	5.52	3.04	3.90	16.69	18.73
Listening	Low-Low	Control	9.96	11.69	15.73	10.64	20.53	16.60	72.96	12.63
		Autism	8.20	7.15	8.45	9.69	15.22	12.41	51.87	24.84
	High Cognitive	Control	10.76	17.57	17.90	13.14	19.75	17.60	75.52	19.74
		Autism	9.84	10.36	9.69	8.95	20.41	15.98	58.74	25.25
	High Social	Control	12.83	15.80	17.48	13.15	17.12	17.75	75.42	16.98
		Autism	8.39	11.81	9.36	10.55	19.10	15.94	58.49	25.63
	High-High	Control	12.35	12.19	20.66	11.44	17.60	14.24	75.37	11.04
		Autism	7.87	8.50	10.01	11.91	17.53	16.11	51.12	26.26

APPENDIX G

MEAN FIXATION DURATIONS

Table G1. Mean Fixation Durations (ms) and Standard Deviations by Group, Participant's Role, and Topic Conditions

		Group					
		Control (*n*=19)		Autism (*n*=19)		Control[a] (*n*=18)	
Participant's Role	Topic	*M*	*SD*	*M*	*SD*	*M*	*SD*
Responding	Low-Low	346	167	320	168	315	102
	High Cognitive	356	110	361	124	342	92
	High Social	346	141	324	150	317	59
	High-High	341	74	307	128	331	64
Listening	Low-Low	756	513	548	283	692	442
	High Cognitive	950	1135	561	262	704	385
	High Social	816	665	521	212	699	441
	High-High	740	474	565	346	667	359

Note. [a]Adjusted means and standard deviation after outlier in the control group was removed.

APPENDIX H

MEAN SCANPATH DISTANCES (PIXELS)

Table H1. Mean Scanpath Distances (Pixels) and Standard Deviations by Group, Participant's Role and Topic Conditions

		Group			
		Control (*n*=19)		Autism (*n*=19)	
Participant's Role	Topic	*M*	*SD*	*M*	*SD*
Responding	Low-Low	160.79	65.96	114.98	54.31
	High Cognitive	147.87	59.64	112.60	44.98
	High Social	162.96	54.27	117.92	47.63
	High-High	175.00	63.94	120.78	58.19
Listening	Low-Low	110.06	39.00	99.67	42.84
	High Cognitive	105.41	54.16	99.50	40.54
	High Social	99.47	54.83	94.54	38.03
	High-High	98.50	44.04	96.91	42.39

APPENDIX I

CORRELATIONS BETWEEN MEASURES OF AUTISM SYMPTOMS AND INDEXES OF VISUAL ATTENTION

Table I1. Correlations between Measures of Autism Symptoms and Indexes of Visual Attention Depending on Participant's Role for Participants in the Autism Group (*n*=19)

		ADOS Com.		ADOS Soc.		ADOS Com.Soc.		SRS[a]	
Variable		*r*	Unadj. *p*	*r*	Unadj. *p*	*r*	Unadj. *p*	*r*	Unadj. *p*
%Face									
	Responding	-0.13	.301	-0.27	.136	-0.24	.158	-0.16	.316
	Listening	-0.15	.268	-0.27	.136	-0.25	.149	.05	.438
Avg. Fixation Duration									
	Responding	-0.28	.124	-0.13	.299	-0.19	.213	.48	.070
	Listening	-0.40	.044	-0.31	.097	-0.37	.058	.14	.344
Avg. Scanpath Distance									
	Responding	-0.15	.274	-0.11	.320	-0.14	.288	-.06	.426
	Listening	-0.11	.326	-0.13	.299	-0.14	.290	-.06	.426

Note. ADOS Com. = ADOS communication score; ADOS Soc. = ADOS Social Score; ADOS Com.Soc.= ADOS Combined Score (Communication + Social); Unadj. *p*= one-tailed *p* value prior to FDR correction for multiple comparisons.
[a]*n*=11.

APPENDIX J

VIEWING PROPORTIONS FOR TOPICS IN WHICH NO SIGNIFICANT CRITICAL PERIODS WERE FOUND

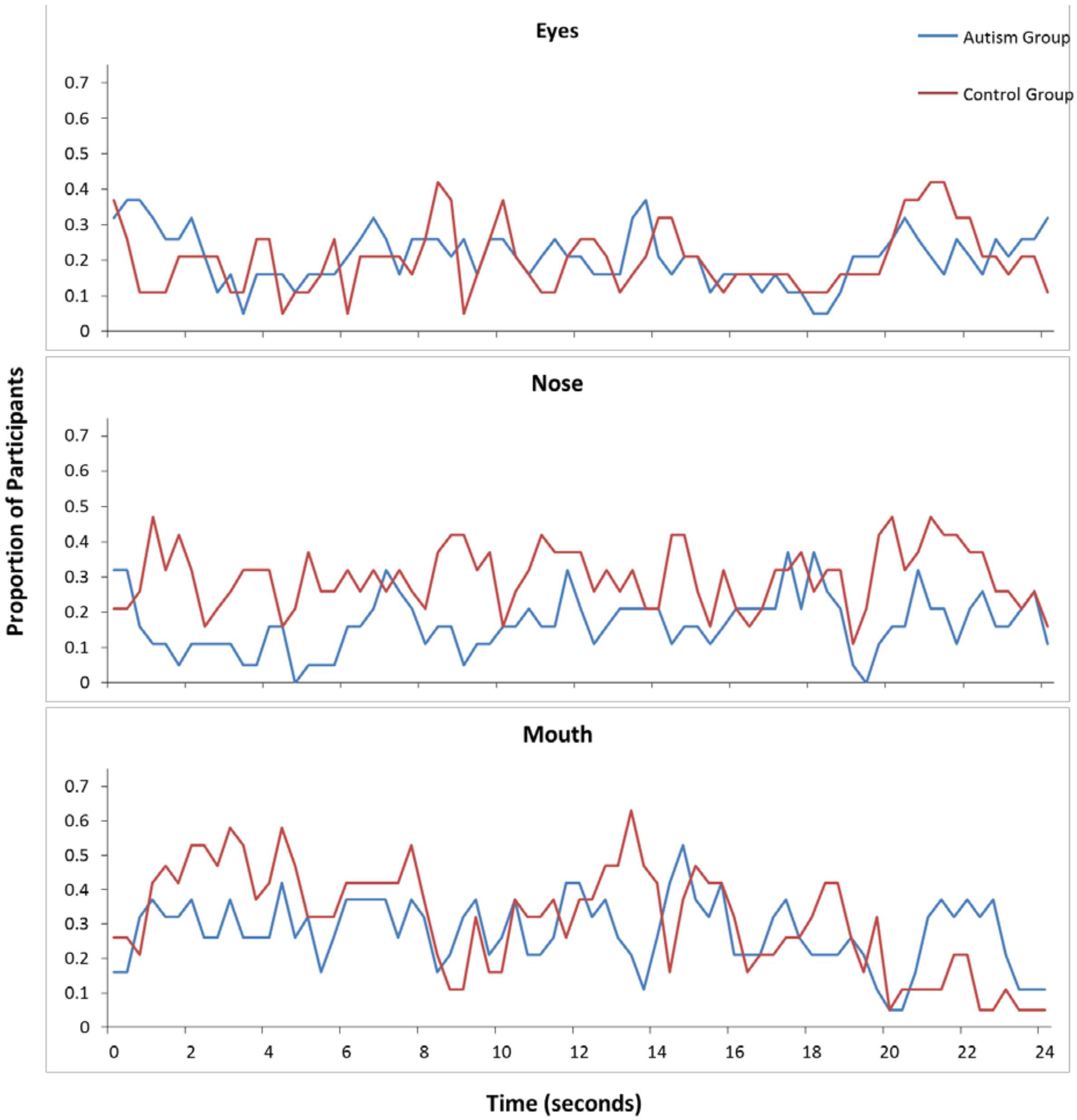

Figure J1. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a High Cognitive topic, "Tell about a time when you were a child, and you felt proud of yourself."

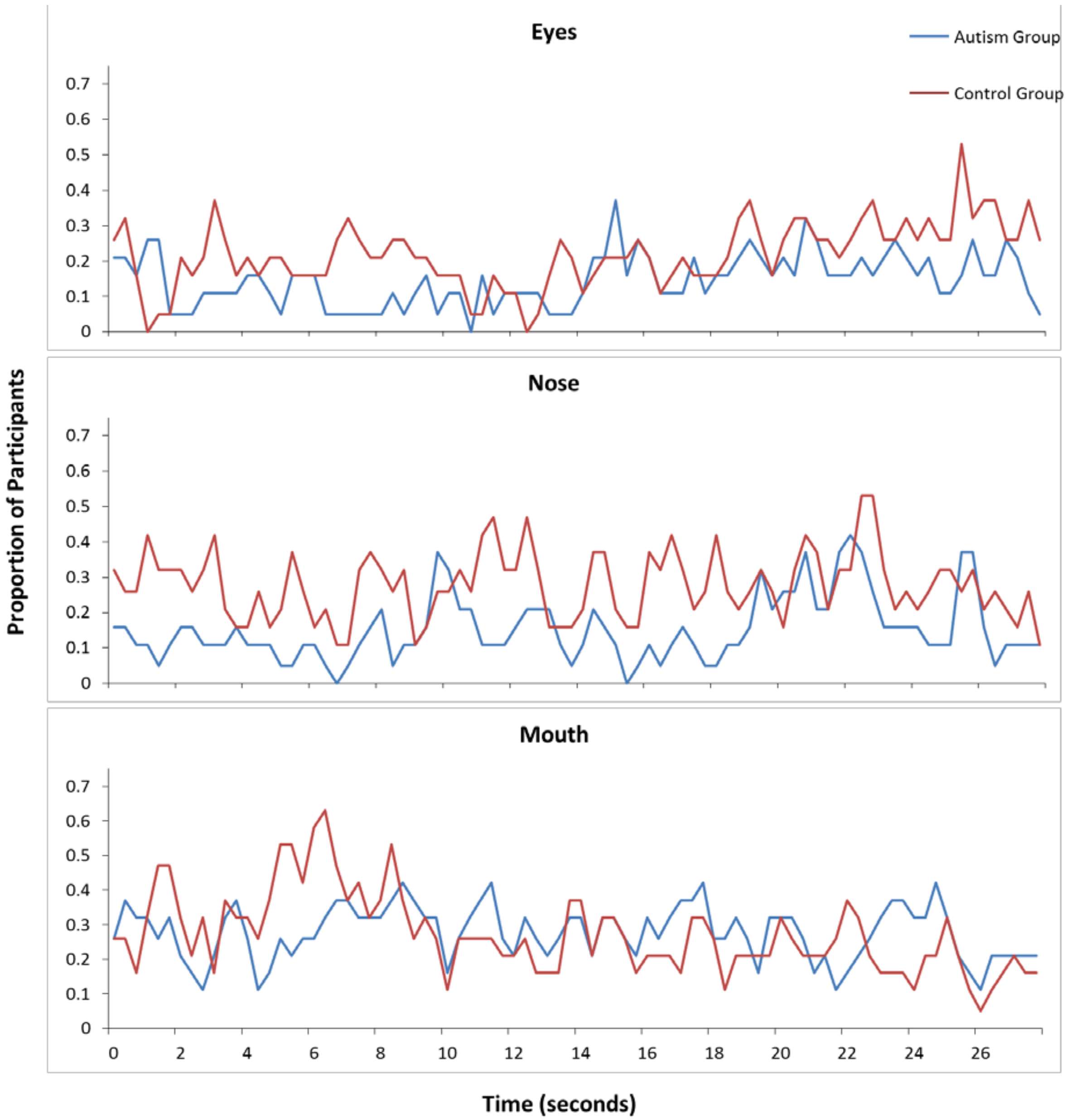

Figure J2. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a High Social topic, "Describe at time in the last week when you felt annoyed or irritated."

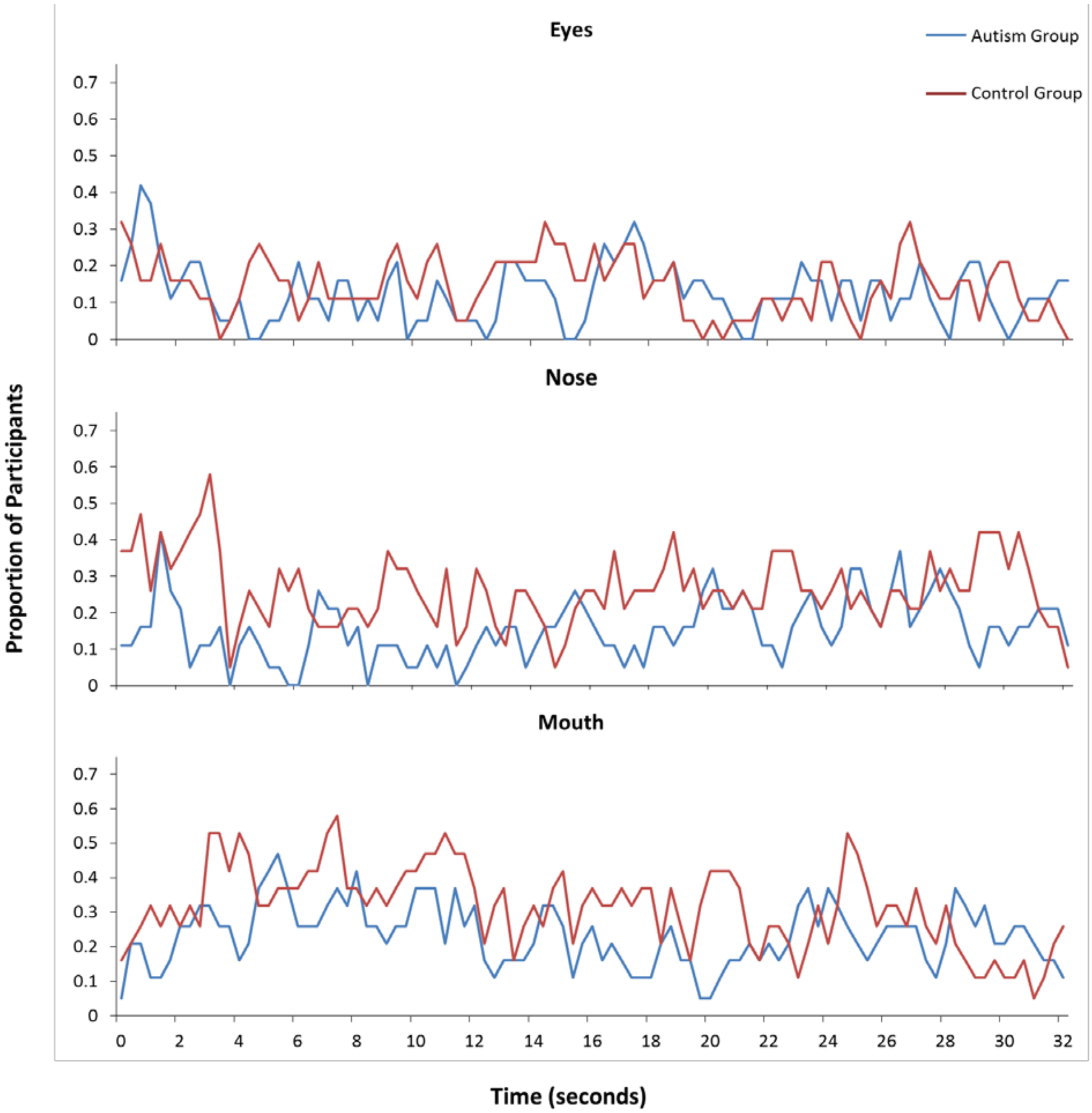

Figure J3. Proportions of participants fixating areas of the confederate's face over time as the confederate responds to a High Social topic, "Describe a time when you were nervous or afraid in the last year."

APPENDIX K

TRANSCRIPTIONS OF THE CONFEDERATE'S RESPONSES FOR TOPICS INCLUDED IN THE FRAME-BY-FRAME ANALYSES

Describe something you can do well and feel confident about doing.

“Well, I’ve been, uh, cooking with my family ever since I was, uh, a little kid, um, so it’s something that I’ve been doing for a long time, and had a lot of practice at, it’s something that I feel pretty confident with, in terms of what I can do, and, uh, making delicious food, so I feel pretty confident in my ability to cook.”

Share a time when you felt happy during the past week.

“Uh, earlier this week, I was given a, uh, big project, uh, to do at work, and, um, I worked really hard on it, and when it was done, I was really happy to, to have it over with, and then my boss told me that I did a great job, and that made me feel really good about all the work I put in and that he thought I did a nice job.”

Tell about a time when you were a child, and you felt proud of yourself.

"Uh, one time wh-when I was, uh, was a kid, umm, I remember graduating from middle, err, from middle school, from 8th grade, uh, I remember finishing the last day of 8th grade and leaving and knowing that I was gonna go to high school the next year and being just really proud that I had gotten through it and really excited that I was going on to something bigger and better."

Describe an exciting trip or vacation that you went on as a child.

"When I was, uh, 9 years old, um, my parents and my sister and I went to, uh, Orlando Florida, and that was the first and only time I've ever been to Disney World, and it was really exciting, and I liked going to Epcot and, um, seeing all the sights down in Orlando and Universal Studios. It was a great time, a lot of fun seeing my, being with my family and my... I had a really nice time."

Describe a time in the last week when you felt annoyed or irritated.

"Well a few days ago I, uh, had to stay late at work, um, because, uh, one of my coworkers, uh, wasn't doing their job, and, uh, there was something that needed to be done, and I couldn't leave because umm..., and I was, uh, pretty upset. I was annoyed and irritated at the fact that, umm, I was having to put more work in to cover something that somebody else, uh, didn't bother to do."

Describe a time when you were nervous or afraid in the last year.

"Well a few months ago I, uh, moved from another city here, uh, to this city and I just finished up school and I was starting a job for the first time and, um, it was a big adjustment. I left all my family, my friends, and, uh, I was really nervous in terms of how things were gonna work out and if I was gonna do well in this new job and, um, you know find new friends and new people to spend time with."

Share a time when you were a child and had your feelings hurt.

“Uh, when I was younger, I had a, uh, speech impediment. I had a hard time saying my r’s and my l’s, and, uh, one time, I had to get up in front of the class and give a presentation, and, uh, afterwards, all the kids called me Elmer Fudd because I had a hard time pronouncing things, so that really hurt my feelings, and it made me pretty embarrassed as well.”

Describe a time when you remember feeling angry as a child.

“One time when I was younger, uh, my mom was, uh, upset at me for doing something. I don’t remember what it was, but, um, her way of getting back to me was we were having a garage sale, and she sold – sold off all my video games, which were my favorite thing to do at the time. I came home from school and, uh, found out my video games were sold, and I had nothing to do, and I was, I was really angry with her for, for doing that to me.”

BIBLIOGRAPHY

Abele, A. (1986). Functions of gaze in social interaction: Communication and monitoring. *Journal of Nonverbal Behavior, 10*(2), 83-101. doi: 10.1007/bf01000006

Aiello, J. R., Derisi, D. T., Epstein, Y. M., & Karlin, R. A. (1977). Crowding and role of interpersonal distance preference. *Sociometry, 40*(3), 271-282. doi: 10.2307/3033534

Anderson, C. J., Colombo, J., & Jill Shaddy, D. (2006). Visual scanning and pupillary responses in young children with Autism Spectrum Disorder. *Journal of Clinical and Experimental Neuropsychology, 28*(7), 1238-1256. doi: K814268033770464

Arnold, J. E., Kam, C. L. H., & Tanenhaus, M. K. (2007). If you say thee uh you are describing something hard: The on-line attribution of disfluency during reference comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(5), 914.

Arnold, J. E., Tanenhaus, M. K., Altmann, R. J., & Fagnano, M. (2004). The old and thee, uh, new disfluency and reference resolution. *Psychological Science, 15*(9), 578-582.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.*): *DSM-5*. Arlington, VA: American Psychiatric Publishing.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (4th ed., text rev.): DSM-IV*. Washington, DC: Author.

Bailly, G., Raidt, S., & Elisei, F. (2010). Gaze, conversational agents, and face-to-face communication. *Speech Communication, 52*(6), 598-612.

Baker, E., & Shaw, M. E. (1980). Reactions to interpersonal distance and topic intimacy a comparison of strangers and friends. *Journal of Nonverbal Behavior, 5*(2), 80-91. doi: 10.1007/bf00986511

Bal, E., Harden, E., Lamb, D., Van Hecke, A. V., Denver, J. W., & Porges, S. W. (2010). Emotion recognition in children with autism spectrum disorders: Relations to eye gaze and autonomic state. *Journal of Autism and Developmental Disorders, 40*(3), 358-370.

Bar-Haim, Y., Shulman, C., Lamy, D., & Reuveni, A. (2006). Attention to eyes and mouth in high-functioning children with autism. *Journal of Autism and Developmental Disorders, 36*(1), 131-137.

Berggren, N., & Derakshan, N. (2013). Attentional control deficits in trait anxiety: why you see them and why you don't. *Biological psychology*, *92*(3), 440-446.

Bindemann, M., Mike Burton, A., & Jenkins, R. (2005). Capacity limits for face processing. *Cognition*, *98*(2), 177-197.

Bombari, D., Mast, F. W., & Lobmaier, J. S. (2009). Featural, configural, and holistic face-processing strategies evoke different scan patterns. *Perception, 38*(10), 1508-1521.

Boraston, Z., & Blakemore, S. J. (2007). The application of eye-tracking technology in the study of autism. *Journal of Physiology, 581*(3), 893-898. doi: jphysiol.2007.133587 [pii]]]>
<![CDATA[10.1113/jphysiol.2007.133587

Bowers, A. L., Crawcour, S. C., Saltuklaroglu, T., & Kalinowski, J. (2010). Gaze aversion to stuttered speech: A pilot study investigating differential visual attention to stuttered and fluent speech. *International Journal of Language & Communication Disorders, 45*(2), 133-144. doi: 10.3109/13682820902763951

Buchan, J. N., Paré, M., & Munhall, K. G. (2007). Spatial statistics of gaze fixations during dynamic face processing. *Social Neuroscience, 2*(1), 1-13. doi: 771239269 [pii]]]>
<![CDATA[10.1080/17470910601043644

Buchan, J. N., Paré, M., & Munhall, K. G. (2008). The effect of varying talker identity and listening conditions on gaze behavior during audiovisual speech perception. *Brain Research, 1242*, 162-171.

Carr, S., & Dabbs, J. (1974). The effects of lighting, distance, and intimacy of topic on verbal and visual behavior. *Sociometry, 37*(4), 592-600.

Cary, M. S. (1978). The role of gaze in the initiation of conversation. *Social Psychology, 41*(3), 269-271.

Chawarska, K., & Shic, F. (2009). Looking but not seeing: Atypical visual scanning and recognition of faces in 2 and 4-year-old children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 39*(12), 1663-1672.

Chawarska, K., Volkmar, F., & Klin, A. (2010). Limited attentional bias for faces in toddlers with autism spectrum disorders. *Archives of General Psychiatry, 67*(2), 178-185.

Constantino, J., & Gruber, C. (2005). Social Responsiveness Scale (SRS) Manual. Los Angeles, California: Western Psychological Services.

Corden, B., Chilvers, R., & Skuse, D. (2008). Avoidance of emotionally arousing stimuli predicts social-perceptual impairment in Asperger's syndrome. *Neuropsychologia, 46*(17920642), 137-147.

Corley, M., MacGregor, L. J., & Donaldson, D. I. (2007). It's the way that you, er, say it: Hesitations in speech affect language comprehension. *Cognition, 105*(3), 658-668. doi: 10.1016/j.cognition.2006.10.010

Curby, K. M., Willenbockel, V., Tanaka, J. W., & Schultz, R. T. (2010). Face processing in autism: Insights from the perceptual expertise framework. In M. T. I. Gauthier, & D. Bub (Ed.), *Perceptual expertise: Bridging brain, behavior* (pp. 139-166). New York: Oxford University Press.

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H. H., . . . Davidson, R. J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience, 8(4), 519-526.*

Dawson, G., Webb, S. J., & McPartland, J. (2005). Understanding the nature of face processing impairment in autism: Insights from behavioral and electrophysiological studies. *Developmental Neuropsychology, 27*(3), 403-424.

Doherty-Sneddon, G., Bonner, L., & Bruce, V. (2001). Cognitive demands of face monitoring: Evidence for visuospatial overload. *Memory & Cognition, 29*(7), 909-919.

Doherty-Sneddon, G., Bruce, V., Bonner, L., Longbotham, S., & Doyle, C. (2002). Development of gaze aversion as disengagement from visual information. *Developmental Psychology, 38*(12005386), 438-445.

Doherty-Sneddon, G., Phelps, F., & Clark, J. (2007). Development of gaze aversion: Qualitative changes over the early school years. *British Journal of Developmental Psychology, 25*(4), 513-526. doi: 10.1348/026151006x172018

Doherty-Sneddon, G., & Phelps, F. G. (2005). Gaze aversion: A response to cognitive or social difficulty? *Memory & Cognition, 33*(4), 727-733.

Doherty-Sneddon, G., Riby, D. M., Calderwood, L., & Ainsworth, L. (2009). Stuck on you: Face-to-face arousal and gaze aversion in Williams syndrome. *Cognitive Neuropsychiatry, 14*(6), 510-523.

Doherty-Sneddon, G., Riby, D. M., & Whittle, L. (2012). Gaze aversion as a cognitive load management strategy in autism spectrum disorder and Williams syndrome. *Journal of Child Psychology and Psychiatry, 53*(4), 420-430.

Doherty-Sneddon, G., Whittle, L., & Riby, D. M. (2013). Gaze aversion during social style interactions in autism spectrum disorder and Williams syndrome. *Research in Developmental Disabilities, 34*(1), 616-626.

Edelmann, R. J., & Hampson, S. E. (1981). Embarrassment in dyadic interaction. *Social Behavior and Personality, 9*(2), 171-178. doi: 10.2224/sbp.1981.9.2.171

Exline, R., Gray, D., & Schuette, D. (1965). Visual Behavior in a dyad as affected by interview content and sex of respondent. *Journal of Personality and Social Psychology, 95*, 201-209.

Falck-Ytter, T. (2008). Face inversion effects in autism: A combined looking time and pupillometric study. *Autism Research, 1*(5), 297-306.

Falck-Ytter, T., Fernell, E., Gillberg, C., & von Hofsten, C. (2010). Face scanning distinguishes social from communication impairments in autism. *Developmental Science, 13*(6), 864-875.

Falck-Ytter, T., von Hofsten, C., Gillberg, C., & Fernell, E. (2013). Visualization and analysis of eye movement data from children with typical and atypical development. *Journal of Autism and Developmental Disorders, 43*(10), 2249-2258.

Fletcher-Watson, S., Leekam, S. R., Benson, V., Frank, M. C., & Findlay, J. M. (2009). Eye-movements reveal attention to social information in autism spectrum disorder. *Neuropsychologia, 47*(1), 248-257.

Foulsham, T., Walker, E., & Kingstone, A. (2011). The where, what and when of gaze allocation in the lab and the natural environment. *Vision Research, 51*(17), 1920-1931. doi: http://dx.doi.org/10.1016/j.visres.2011.07.002

Fox Tree, J. E. (2001). Listeners' uses of um and uh in speech comprehension. *Memory & Cognition, 29*(2), 320-326.

Gamer, M., & Hecht, H. (2007). Are you looking at me? Measuring the cone of gaze. *Journal of Experimental Psychology: Human Perception and Performance, 33*(3), 705.

García-Pérez, R. M., Lee, A., & Hobson, R. P. (2007). On intersubjective engagement in autism: A controlled study of nonverbal aspects of conversation. *Journal of Autism and Developmental Disorders, 37*(7), 1310-1322. doi: 10.1007/s10803-006-0276-x

Gastgeb, H. Z., Wilkinson, D. A., Minshew, N. J., & Strauss, M. S. (2011). Can individuals with autism abstract prototypes of natural faces? *Journal of Autism and Developmental Disorders, 41*(12), 1609-1618.

Glenberg, A. M., Schroeder, J. L., & Robertson, D. A. (1998). Averting the gaze disengages the environment and facilitates remembering. *Memory & Cognition, 26*(4), 651-658.

Goffaux, V., Jemel, B., Jacques, C., Rossion, B., & Schyns, P. G. (2003). ERP evidence for task modulations on face perceptual processing at different spatial scales. *Cognitive Science, 27*(2), 313-325.

Goodacre, R., & Zadro, L. (2010). O-Cam: A new paradigm for investigating the effects of ostracism. *Behavior Research Methods, 42*(3), 768-774. doi: 10.3758/brm.42.3.768

Gore, J. S. (2009). The interaction of sex, verbal, and nonverbal cues in same-sex first encounters. *Journal of Nonverbal Behavior, 33*(4), 279-299. doi: 10.1007/s10919-009-0074-1

Griffin, Z. (2004). Why look? Reasons for eye movements related to language production. In J. Henderson & F. Ferreira (Eds.), *The integration of language, vision, and action: Eye movements and the visual world* (pp. 213-247). New York, NY: Psychology Press.

Hanna, J. E., & Brennan, S. E. (2007). Speakers' eye gaze disambiguates referring expressions early during face-to-face conversation. *Journal of Memory and Language, 57*(4), 596-615. doi: 10.1016/j.jml.2007.01.008

Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognition in autism spectrum disorders: A review of behavioral and neuroimaging studies. *Neuropsychology Review, 20*(3), 290-322.

Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in Cognitive Science, 7*(11), 498-504. doi: S1364661303002481 [pii]

Henderson, J. M., & Hollingworth, A. (1999). High-level scene perception. *The Annual Review of Psychology, 50*, 243-271. doi: 10.1146/annurev.psych.50.1.243

Henderson, J. M., Williams, C. C., & Falk, R. J. (2005). Eye movements are functional during face learning. *Memory and Cognition, 33*(1), 98-106.

Hernandez, N., Metzger, A., Magne, R., Bonnet-Brilhault, F., Roux, S., Barthelemy, C., & Martineau, J. (2009). Exploration of core features of a human face by healthy and autistic adults analyzed by visual scanning. *Neuropsychologia, 47*(4), 1004-1012.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2003). Social phobics do not see eye to eye: A visual scanpath study of emotional expression processing. *Journal of Anxiety Disorders, 17*(1), 33-44. doi: S0887618502001809

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2004). Face to face: Visual scanpath evidence for abnormal processing of facial expressions in social phobia. *Psychiatry Research, 127*(1-2), 43-53.

Howell, A., & Conway, M. (1990). Perceived intimacy of expressed emotion. *Journal of Social Psychology, 130*(4), 467-476.

Hsiao, J. H., & Cottrell, G. (2008). Two fixations suffice in face recognition. *Psychological Science, 19*(10), 998-1006. doi: PSCI2191 [pii]]]>
<![CDATA[10.1111/j.1467-9280.2008.02191.x

Ingvalson, E. M., & Wenger, M. J. (2005). A strong test of the dual-mode hypothesis. *Perception and Psychophysics, 67*(1), 14-35.

Itier, R. J., Villate, C., & Ryan, J. D. (2007). Eyes always attract attention but gaze orienting is task-dependent: Evidence from eye movement monitoring. *Neuropsychologia, 45*(5), 1019-1028. doi: 10.1016/j.neuropsychologia.2006.09.004

Izard, C., Fine, S., Schultz, D., Mostow, A., Ackerman, B., & Youngstrom, E. (2001). Emotion knowledge as a predictor of social behavior and academic competence in children at risk. *Psychological Science, 12*(11294223), 18-23.

Jemel, B., Mottron, L., & Dawson, M. (2006). Impaired face processing in autism: Fact or artifact? *Journal of Autism and Developmental Disorders, 36*(1), 91-106.

Jones, W., Carr, K., & Klin, A. (2008). Absence of preferential looking to the eyes of approaching adults predicts level of social disability in 2-year-old toddlers with autism spectrum disorder. *Archives of General Psychiatry, 65*(8), 946-954.

Joseph, R. M., Ehrman, K., McNally, R., & Keehn, B. (2008). Affective response to eye contact and face recognition ability in children with ASD. *Journal of the International Neuropsychological Society, 14*(6), 947-955.

Karatekin, C. (2007). Eye tracking studies of normative and atypical development. *Developmental Review, 27*(3), 283-348. doi: 10.1016/j.dr.2007.06.006

Kastner, S., & Ungerleider, L. G. (2001). The neural basis of biased competition in human visual cortex. *Neuropsychologia, 39*(12), 1263-1276.

Kirchner, J. C., Hatri, A., Heekeren, H. R., & Dziobek, I. (2011). Autistic symptomatology, face processing abilities, and eye fixation patterns. *Journal of Autism and Developmental Disorders, 41*(2), 158-167. doi: 10.1007/s10803-010-1032-9

Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological bulletin, 100*(1), 78.

Kliemann, D., Dziobek, I., Hatri, A., Steimke, R., & Heekeren, H. R. (2010). Atypical reflexive gaze patterns on emotional faces in autism spectrum disorders. *Journal of Neuroscience, 30*(37), 12281-12287.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59*(9), 809-816. doi: yoa10221

Kogan, M. D., Blumberg, S. J., Schieve, L. A., Boyle, C. A., Perrin, J. M., Ghandour, R. M., . . . van Dyck, P. C. (2009). Prevalence of parent-reported diagnosis of autism spectrum disorder among children in the US, 2007. *Pediatrics, 124*(5), 1395-1403. doi: 10.1542/peds.2009-1522

Laidlaw, K. E., Foulsham, T., Kuhn, G., & Kingstone, A. (2011). Potential social interactions are important to social attention. *Proceedings of the National Academy of Sciences, 108*(14), 5548-5553.

Lander, K., & Davies, R. (2007). Exploring the role of characteristic motion when learning new faces. *The Quarterly Journal of Experimental Psychology,60*(4), 519-526.

Lansing, C. R., & McConkie, G. W. (1999). Attention to facial regions in segmental and prosodic visual speech perception tasks. *Journal of Speech Language and Hearing Research, 42*(3), 526-539.

Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General*, *133*(3), 339.

Liversedge, S. P., & Findlay, J. M. (2000). Saccadic eye movements and cognition. *Trends in Cognitive Science, 4*(1), 6-14. doi: S1364-6613(99)01418-7

Lord, C., & Haith, M. M. (1974). The perception of eye contact. *Perception and Psychophysics, 16*(3), 413-416.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., . . . Rutter, M. (2000). The Autism Diagnostic Observation Schedule-generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30(3), 205-223*.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24(5), 659-685.*.

Markson, L., & Paterson, K. B. (2009). Effects of gaze-aversion on visual-spatial imagination. *British Journal of Psychology, 100*(Pt 3), 553-563. doi: 309614 [pii]]]>
<![CDATA[10.1348/000712608X371762

McKone, E., & Robbins, R. (2011). Are faces special? In A. Calder, Rhodes, G., Johnson, M., & Haxby, J (Ed.), *Oxford handbook of face perception* (pp. 149-176). Oxford: Oxford University Press

McPartland, J. C., Webb, S. J., Keehn, B., & Dawson, G. (2011). Patterns of visual attention to faces and objects in autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41*(20499148), 148-157.

Morrison, R. L., & Bellack, A. S. (1981). The role of social perception in social skill. *Behavior Therapy, 12*(1), 69-79. doi: 10.1016/s0005-7894(81)80107-4

Mostow, A. J., Izard, C. E., Fine, S., & Trentacosta, C. J. (2002). Modeling emotional, cognitive, and behavioral predictors of peer acceptance. *Child Development, 73*(12487493), 1775-1787.

Nadig, A., Lee, I., Singh, L., Bosshart, K., & Ozonoff, S. (2010). How does the topic of conversation affect verbal exchange and eye gaze? A comparison between typical development and high-functioning autism. *Neuropsychologia, 48*(9), 2730-2739.

Nakano, T., Tanaka, K., Endo, Y., Yamane, Y., Yamamoto, T., Nakano, Y., . . . Kitazawa, S. (2010). Atypical gaze patterns in children and adults with autism spectrum disorders dissociated from developmental changes in gaze behaviour. *Proceedings of the Royal Society B: Biological Sciences, 277*(1696), 2935-2943. doi: rspb.2010.0587 [pii]]]>
<![CDATA[10.1098/rspb.2010.0587

Neumann, D., Spezio, M. L., Piven, J., & Adolphs, R. (2006). Looking you in the mouth: Abnormal gaze in autism resulting from impaired top-down modulation of visual attention. *Social Cognitive and Affective Neuroscience, 1*(18985106), 194-202.

Norbury, C. F., Brock, J., Cragg, L., Einav, S., Griffiths, H., & Nation, K. (2009). Eye-movement patterns are associated with communicative competence in autistic spectrum disorders. *Journal of Child Psychology and Psychiatry, 50*(7), 834-842.

Paré, M., Richler, R. C., ten Hove, M., & Munhall, K. (2003). Gaze behavior in audiovisual speech perception: The influence of ocular fixations on the McGurk effect. *Perception and Psychophysics, 65*(4), 553-567.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32(4), 249-261*.

Peterson, M. F., & Eckstein, M. P. (2012). Looking just below the eyes is optimal across face recognition tasks. *Proceedings of the National Academy of Sciences, 109*(48), E3314-E3323.

Peterson, M. F., & Eckstein, M. P. (2013a). Individual differences in eye movements during face identification reflect observer-specific optimal points of fixation. *Psychological Science, 24*(7), 1216-1225.

Peterson, M. F., & Eckstein, M. P. (2013b). Learning optimal eye movements to unusual faces. *Vision Research,* Advance online publication. doi: 10.1016/j.visres.2013.11.005

Phelps, F. G., Doherty-Sneddon, G., & Warnock, H. (2006). Helping children think: Gaze aversion and teaching. *British Journal of Developmental Psychology, 24*, 577-588. doi: 10.1348/026151005x49872

Piepers, D. W., & Robbins, R. A. (2012). A review and clarification of the terms "holistic," "configural," and "relational" in the face perception literature. *Frontiers in Psychology, 3*, 559. doi: 10.3389/fpsyg.2012.00559

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*(3), 372.

Riby, D., Doherty-Sneddon, G., & Whittle, L. (2012). Face-to-face interference in typical and atypical development. *Developmental Science, 15*(2), 281-291. doi: 10.1111/j.1467-7687.2011.01125.x

Riby, D. M., Doherty-Sneddon, G., & Bruce, V. (2008). Exploring face perception in disorders of development: Evidence from Williams syndrome and autism. *Journal of Neuropsychology, 2*(1), 47-64.

Rice, K., Moriuchi, J. M., Jones, W., & Klin, A. (2012). Parsing heterogeneity in autism spectrum disorders: Visual scanning of dynamic social scenes in school-aged children. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(3), 238-248.

Risko, E. F., Laidlaw, K. E., Freeth, M., Foulsham, T., & Kingstone, A. (2012). Social attention with real versus reel stimuli: Toward an empirical approach to concerns about ecological validity. *Frontiers in Human Neuroscience, 6*, 1-11.

Roberson-Nay, R., Strong, D. R., Nay, W. T., Beidel, D. C., & Turner, S. M. (2007). Development of an abbreviated Social Phobia and Anxiety Inventory (SPAI) using item response theory: the SPAI-23. *Psychological Assessment*, *19*(1), 133-145. doi: 2007-03014-011 [pii]]]>
<![CDATA[10.1037/1040-3590.19.1.133

Rothkopf, C. A., Ballard, D. H., & Hayhoe, M. M. (2007). Task and context determine where you look. *Journal of Vision*, 7(14), 1-20.

Rump, K. M., Giovannelli, J. L., Minshew, N. J., & Strauss, M. S. (2009). The development of emotion recognition in individuals with autism. *Child Development, 80*(5), 1434-1447.

Rutherford, M. D., & Towns, A. M. (2008). Scan path differences and similarities during emotion perception in those with and without autism spectrum disorders. *Journal of Autism and Developmental Disorders, 38*(7), 1371-1381. doi: 10.1007/s10803-007-0525-7

Sasson, N. J. (2006). The development of face processing in autism. *Journal of Autism and Developmental Disorders, 36*(3), 381-394.

Schwarzer, G., Huber, S., & Dümmler, T. (2005). Gaze behavior in analytical and holistic face processing. *Memory and Cognition, 33*(2), 344-354.

Schyns, P. G., Bonnar, L., & Gosselin, F. (2002). Show me the features! Understanding recognition from the use of visual information. *Psychological Science, 13*(5), 402-409.

Searcy, J. H., & Bartlett, J. C. (1996). Inversion and processing of component and spatial–relational information in faces. *Journal of Experimental Psychology: Human Perception and Performance, 22*(4), 904.

Shaffer, D. R., Smith, J. E., & Tomarelli, M. (1982). Self-monitoring as a determinant of self-disclosure reciprocity during the acquaintance process. *Journal of Personality and Social Psychology, 43*(1), 163-175.

Shic, F., Macari, S., & Chawarska, K. (2014). Speech disturbs face scanning in 6-month-old infants who develop autism spectrum disorder. *Biological Psychiatry, 75*(3), 231-237. doi: http://dx.doi.org/10.1016/j.biopsych.2013.07.009

Snell, W. E., Miller, R. S., & Belk, S. S. (1988). Development of the emotional self-disclosure scale. *Sex Roles*, *18*(1), 59-73. doi: 10.1007/bf00288017

Speer, L. L., Cook, A. E., McMahon, W. M., & Clark, E. (2007). Face processing in children with autism: Effects of stimulus contents and type. *Autism, 11*(3), 265-277.

Spezio, M. L., Adolphs, R., Hurley, R. S., & Piven, J. (2007). Analysis of face- gaze in autism using "Bubbles". *Neuropsychologia, 45*(1), 144-151.

Sterling, L., Dawson, G., Webb, S., Murias, M., Munson, J., Panagiotides, H., & Aylward, E. (2008). The role of face familiarity in eye tracking of faces by individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 38*(9), 1666-1675.

Sundstrom, E. (1978). A test of equilibrium theory: Effects of topic intimacy and proximity on verbal and nonverbal behavior in pairs of friends and strangers. *Journal of Nonverbal Behavior, 3*(1), 3-16. doi: 10.1007/bf01114528

Tantam, D., Holmes, D., & Cordess, C. (1993). Nonverbal expression in autism of Asperger type. *Journal of Autism and Developmental Disorders, 23*(1), 111-133.

Turner, S., Beidel, D., & Dancu, C. (1996). *Social Phobia and Anxiety Inventory: Manual*. Toronto, Ontario: Multi-Health Systems Inc.

van der Geest, J., Kemner, C., Verbaten, M., & van Engeland, H. (2002). Gaze behavior of children with pervasive developmental disorder toward human faces: A fixation time study. *Journal of Child Psychology and Psychiatry, 43*(5), 669-678.

Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 45*(14959806), 135-170.

Vredeveldt, A., Hitch, G. J., & Baddeley, A. D. (2011). Eye closure helps memory by reducing cognitive load and enhancing visualization. *Memory & Cognition*. doi: 10.3758/s13421-011-0098-8

Wechsler, D. (1999). *WASI Manual.* . San Antonio, TX: Psychological Corporation.

Weigelt, S., Koldewyn, K., & Kanwisher, N. (2012). Face identity recognition in autism spectrum disorders: A review of behavioral studies. *Neuroscience & Biobehavioral Reviews, 36*(3), 1060-1084.

Weissman, M. M., Wickramaratne, P., Adams, P., Wolk, S., Verdeli, H., & Olfson, M. (2000). Brief screening for family psychiatric history: The Family History Screen. *Archives of General Psychiatry, 57*(7), 675-682. doi: 10.1001/archpsyc.57.7.675

Wenger, M. J., & Townsend, J. T. (2000). Basic response time tools for studying general processing capacity in attention, perception, and cognition. *The Journal of general psychology*, *127*(1), 67-99.

Wenger, M. J., & Townsend, J. T. (2001). Faces as gestalt stimuli: Process characteristics. In Wenger, M. J., & Townsend, J. T. (Eds.). Computational, geometric, and process perspectives on facial cognition: Contexts and challenges (pp. 229-284). Psychology Press.

Wieser, M. J., Pauli, P., Alpers, G. W., & Mühlberger, A. (2009). Is eye to eye contact really threatening and avoided in social anxiety?--An eye-tracking and psychophysiology study. *Journal of Anxiety Disorders*, *23*(1), 93-103. doi: 10.1016/j.janxdis.2008.04.004

Wilkinson, G., & Robertson, G. (2006). *Wide Range Achievement* Test*—Fourth Edition*. Lutz, FL: Psychological Assessment Resources.

Williams, C. C., & Henderson, J. M. (2007). The face inversion effect is not a consequence of aberrant eye movements. *Memory & Cognition*, *35*(8), 1977-1985.

Yu, C., Yurovsky, D., & Xu, T. L. (2012). Visual data mining: An exploratory approach to analyzing temporal patterns of eye movements. *Infancy*, *17*(1), 33-60.

Zhang, J., & Kalinowski, J. (2012). Culture and listeners' gaze responses to stuttering. *International Journal of Language & Communication Disorders*, *47*(4), 388-397. doi: 10.1111/j.1460-6984.2012.00152.x