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How does the topic of conversation affect verbal exchange and eye gaze? A comparison between typical development and high-functioning autism

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Abstract

Conversation is a primary area of difficulty for individuals with high-functioning autism (HFA) although they have unimpaired formal language abilities. This likely stems from the unstructured nature of face-to-face conversation as well as the need to coordinate other modes of communication (e.g. eye gaze) with speech. We conducted a quantitative analysis of both verbal exchange and gaze data obtained from conversations between children with HFA and an adult, compared with those of typically-developing children matched on language level. We examined a new question: How does speaking about a topic of interest affect reciprocity of verbal exchange and eye gaze? Conversations on generic topics were compared with those on individuals' circumscribed interests, particularly intense interests characteristic of HFA. Two opposing hypotheses were evaluated. Speaking about a topic of interest may improve reciprocity in conversation by increasing participants' motivation and engagement. Alternatively, it could engender more one-sided interaction, given the engrossing nature of circumscribed interests. In their verbal exchanges HFA participants demonstrated decreased reciprocity during the interest topic, evidenced by fewer contingent utterances and more monologue-style speech. Moreover, a measure of stereotyped behaviour and restricted interest symptoms was inversely related to reciprocal verbal exchange. However, both the HFA and comparison groups looked significantly more to their partner's face during the interest than generic topic. Our interpretation of results across modalities is that circumscribed interests led HFA participants to be less adaptive to their partner verbally, but speaking about a highly practiced topic allowed for increased gaze to the partner. The function of this increased gaze to partner may differ for the HFA and comparison groups.

Keywords

conversation; high-functioning autism; eye-gaze; circumscribed interests; restricted and repetitive behaviours

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Conversation is an area of substantial difficulty for individuals with high-functioning autism although they have relatively unimpaired formal language. This decoupling of conversational abilities and formal language (e.g. phonology and syntax) is also observed developmentally. Whereas conversational skills improve alongside indices of formal language ability such as MLU (mean length of utterance) in both typically-developing children and children with developmental delays other than autism, this is not the case for children with autism (Tager-Flusberg & Anderson, 1991). In fact, in individuals with autism atypical and off-topic utterances that impede the flow of reciprocal conversation actually increase with formal language ability (Volden & Lord, 1991).

Verbal Exchange

Difficulties with face-to-face conversational interaction are likely to stem from its open-ended and relatively unstructured nature. Previous research has identified differences in back-and-forth verbal exchange between children with autism and comparison groups matched on formal language abilities (Capps, Kehres, & Sigman, 1998; Tager-Flusberg & Anderson, 1991; Volden & Lord, 1991). One area of difficulty involves topic maintenance; children with autism were more likely to provide non-contingent responses to their parents' statements than children with Down Syndrome, and their contingent responses do not increase with MLU at the same rate as they do in peers without autism (Tager-Flusberg & Anderson, 1991). Another area of difficulty is providing the appropriate amount of information for a situation: within contingent responses, those that extend a topic by providing new and relevant information are decreased in autism relative to comparison groups (Capps, Kehres, & Sigman, 1998; Tager-Flusberg & Anderson, 1991). A third characteristic of conversation in autism is the increased use of repetitive or stereotyped phrases and idiosyncratic utterances (Capps, et al., 1998; Volden & Lord, 1991). While these studies focused their investigation on one aspect of verbal exchange, in the present study we will examine all three of these areas found to be characteristic of conversation in autism.

Gaze to social stimuli

Another source of difficulty with conversation is its demands for the coordination of multiple modes of communication along with speech. The most striking and commonly noted mode of nonverbal communication that is atypical in individuals with autism is the modulation of eye gaze. In fact reduction in direct gaze with others and a failure to coordinate gaze with gestures and vocalizations is an early indicator of autism in infancy (Osterling, Dawson, & Munson, 2002). Research on visual attention to social stimuli in adults with autism demonstrates that their scanning of faces tends to differ from that of normal comparison groups as well. For example, Klin et al. (2002) tracked participants' eye movements as they watched movie clips depicting dramatic social interactions between actors. They found that adults with autism and normal IQ looked to the actors' eyes for a significantly shorter proportion of time than a matched comparison group, yet they looked to the actors' mouths for a longer proportion of time than the comparison group (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Dalton et al. (2005) found that, when viewing still faces on a computer screen, adults with autism looked for a shorter proportion of time to the eye region than a comparison group, but both groups looked to the mouth region and to the face overall for similar amounts of time. Therefore in adults with autism findings indicate different patterns of viewing faces, rather than a sheer reduction of time spent looking at faces. It should be noted that so far studies with adults with autism have not been conducted during live interactions, which will be the focus of the present study.

Studies using more natural stimuli or settings report that the amount of time spent attending to people does not differ between adolescents with autism and well-matched comparison groups

(Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009; García-Pérez, Lee, & Hobson, 2007; Norbury, et al., 2009). The most pertinent of these to the current study was conducted by García-Pérez, Lee, and Hobson (2007) who examined face-to-face interactions between an adult partner and either adolescents with autism and language delay or adolescents with non-autism developmental delays. Gaze directed to the partner's face versus other regions was coded from video of the session. No group differences were found in attention to partner's face; both groups spent 30–40% of the time looking toward their partner. Thus the literature to date reveals a complex developmental trajectory in the social use of eye gaze in autism and highlights differences that may surface depending on developmental level, visual and social setting, and range of the autism spectrum.

Given the complexity inherent to face-to-face conversation and the fact that structured experimental tasks can mask difficulties normally experienced by individuals with autism, it is essential to study communicative behaviour in as natural a setting as possible to obtain an accurate assessment of it. Although this proposal is not new (Boraston & Blakemore, 2007; Klin, et al., 2002), few studies have empirically examined central aspects of communication “in vivo,” as individuals engage in face-to-face interaction with a conversational partner. This study addresses this gap by conducting a detailed analysis of two modes of communication in the same sample: both verbal exchange and eye gaze, as obtained by a head-mounted eye-tracker, during conversations between an adult partner and children with either high-functioning autism or typical development. Our rationale for examining these modes of communication in conjunction is that the face-to-face setting provides a more veridical sample of the conversational difficulties observed in autism, which stem from nonverbal behaviours as well as verbal exchange. Furthermore, many interventions for autism target gaze behaviour (Mirenda, Donnellan, & Yoder, 1983) and take it to be a crucial prerequisite for more complex social and communicative behaviours (e.g. Lovaas, Berberich, Perloff, & Schaeffer, 1996, as cited in Arnold, Semple, Beale & Fletcher-Flynn, 2000). To evaluate the appropriateness of such treatment goals it is important to establish what typical use of gaze looks in natural conversational settings, and whether and how children with autism differ in this regard.

Based on previous findings on verbal aspects of conversation (Capps, Kehres, & Sigman, 1998; Tager-Flusberg & Anderson, 1991; Volden & Lord, 1991), we hypothesized that participants with autism would display reduced reciprocity and partner adaptation in their verbal exchanges, as manifested in reduced topic maintenance, reduced provision of an appropriate amount of information, and increased production of idiosyncratic utterances that derail the flow of conversation (to be described in more detail below). With respect to eye gaze, we were neutral in our hypothesis regarding group differences; participants may look less towards their partner during conversational exchange as would be expected based on reduced attention to people in the early development of autism (Osterling, Dawson, & Munson, 2002), or they may display a similar amount of gaze to their partner given findings from adolescents with autism viewing naturalistic video scenes (Fletcher-Watson, et al., 2009; Norbury, et al., 2009) or engaged in face-to-face conversation (García-Pérez, Lee, & Hobson, 2007; Mirenda, Donnellan & Yoder, 1983).

We have yet to consider the cause of these potential group differences. What would lead participants with autism to be less likely to stay on the topic of conversation though they do not differ from the comparison group with respect to formal language ability? One possibility we explored is that they have less inherent interest and engagement in social interaction for its own sake. This idea has been most clearly articulated in Dawson and colleagues' (Dawson, Webb, & McPartland, 2005; Dawson, Webb, Wijsman, et al., 2005) social motivation hypothesis of autism. These authors propose that reduced early social motivation in infancy, as observed in reduced social smiling and displays of positive affect alongside preverbal

communication, engenders less attention to social stimuli such as faces and voices, which then fails to provide neural reward mechanisms with the necessary input to develop expert processing of social stimuli and associated reward values. With respect to conversation, we propose that this decrease in social orienting and intrinsic social reward may hamper the adaption of speech to a listener's perspective, including the production of contingent utterances and those that convey an appropriate amount of information. Similarly, early in development decreased social orienting would also lead to decreased eye gaze to a partner in communicative settings. However, over the course of development children may learn to look to faces for reasons other than social engagement. In the context of face-to-face conversation, gaze to face can have a number of functions: automatic orienting to social stimuli, cross-modal access to speech via lip-reading, and/or social engagement.

Circumscribed interests and motivation

Following this hypothesis, a generic topic of conversation may provide inherent social motivation to individuals without autism, leading them to communicate in a contingent manner with their conversational partner, whereas the same topic is unlikely to induce the same level of engagement in individuals with autism. What would happen, however, if a topic of specific interest were introduced? Would this be highly motivating and engender more reciprocal exchange? Individuals with autism demonstrate circumscribed interests (hereafter CIs): patterns of interest unusual in their narrowness and/or intensity of pursuit. The content of CIs can change over time and may be very similar to the interests of typically developing children (e.g., video games or Harry Potter), or may be unusual in content (e.g., 18th century military history or a local public transportation system). They are observed more often in individuals with Asperger Syndrome or HFA than in typical peers, and CI symptoms increase in severity with age, in contrast to gains made in social interaction and communication (South, Ozonoff, & McMahon, 2005). Consequently CIs are a significant aspect of the behaviour, activities and interests of individuals of ASD from school-age onwards, and are often preferred topics of discussion (South, et al., 2005). We took advantage of the presence of CIs in our participants with autism to examine the effects of a potentially motivating topic by comparing conversations on generic topics (siblings, pets) with those on participants' CIs (for the HFA group) or on their favourite hobby (for the comparison group).

We evaluate two possibilities regarding the effect of CIs on conversation. The first builds on proposals from treatment research with young children with autism which has explored the use of CIs, in the form of preferred toys or objects, as a motivating tool in behavioural therapy. Multiple case studies on behavioural therapy with minimally-verbal children have reported improvements in verbal and nonverbal communication in the presence of materials related to a child's CIs (Baker, Koegel, & Koegel, 1998; Boyd, Conroy, Mancil, Nakao, & Alter, 2007; Vismara & Lyons, 2007). In particular, Vismara & Lyons (2007) report that, although not directly targeted in treatment, joint attention bids for the purpose of sharing enjoyment increased through the use of toys related to children's CIs; they appeared to facilitate social interaction and make it more rewarding. Initial findings such as these would suggest that, for higher-functioning children with autism, conversing about a CI may also result in increased motivation to engage with a conversational partner. On this view, conversing about a topic of interest, relative to a generic topic, would have positive effects on the conversational performance of individuals with autism. CIs may result in increased reciprocity of verbal exchange (as reflected in improved topic maintenance, reduced atypical phrases) and increased eye contact with the partner.

A second possibility is that CIs would have the opposite effect on older, higher-functioning individuals with autism. This prediction stems from observations that CIs are much more restricted, focused, and all-consuming than typical hobbies or interests; so while they may be

motivating for the individual, this motivation is perseverative and non-reciprocal in nature. Boyd et al. (2007) highlighted several attributes of CIs consistent with this view: individuals with autism persistently accumulate large amounts of information or facts related to their CIs, to the exclusion of other topics; others have a difficult time redirecting an individual with autism from physically interacting with or talking about their CI; and there is a high intensity or focus on the CI, much more than is observed in the average interest. Given this, conversing about a CI, relative to a generic topic, may lead to more stereotyped and monologue-style speech in individuals with autism (reflected in reduced topic maintenance, increased atypical phrases), and reduced eye contact with the partner.

For the typically-developing group we predicted less significant or no effect of topic on verbal exchange, as these participants were expected have normal social motivation and therefore to follow Grice's conversational maxims – implicit cooperative guidelines we rely on when communicating with others (Grice, 1975). Consequently we expected them to display a default adaptation of language to their partner's perspective that would not differ substantially when conversing about a generic topic or their favourite hobby. However we hypothesized that a higher level of motivation may engender increased social engagement that surfaces as increased gaze to their partner's face when speaking about a favourite hobby.

The present study adds novel dimensions to quantitative research on conversation in high-functioning autism; we examine two modes of face-to-face interaction, verbal exchange as well as eye gaze, in detail in the same sample (prosodic features of speech were also analyzed acoustically, these are presented in Shaw & Nadig, submitted). In addition we explore the effect of a topic of interest on these two modes of communication relative to a generic topic according to the opposing hypotheses outlined above. Finally, while most previous studies utilizing eye-tracking technology to examine attention to social stimuli in autism have used still scenes or videos and tested participants who were in adolescence or adulthood (including Fletcher-Watson et al., 2009; Klin et al., 2002; Norbury et al., 2009), we test a sample of school-age children during a live social interaction. These participants have developed the fluent language skills required to participate in full-fledged conversation but represent an earlier stage in the use of eye gaze that may be less prone to compensatory behaviour for social difficulties that may predominate later in development.

Methods

Participants

The sample included 20 children with high-functioning autism (henceforth HFA) and 17 typically-developing children (abbreviated as TYP, see Table 1 for participant characteristics). Participants were recruited via the University of California at Davis M.I.N.D. Institute database and through community outreach efforts in Sacramento, CA, as part of a larger 3-visit study approved by the UC Davis IRB. Prior to participation informed consent was obtained by all parents and participants.

There were no significant differences between groups with respect to chronological age, gender ratio, language level, or Performance IQ. All participants possessed average or above average formal language ability (standard score of 85 or higher), as assessed by the Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-4; Semel, Wiig & Secord, 2003). Performance IQ was evaluated with the block design and matrix reasoning subtests of the Wechsler Abbreviated Scales of Intelligence (WASI; Weschler, 1999). Parent report data on adaptive skills and social functioning was collected using the Daily Living Skills and Socialization subscales of the Vineland Adaptive Behaviour Scales-II (VABS; Sparrow, Cicchetti & Balla, 2005).

Participants in the HFA group met full DSM-IV diagnostic criteria for Autistic Disorder. Based on parent report, 8 of the 20 participants had a history of early language delay, defined as onset of first words after the age of 2 years or phrase speech after the age of 3 years.¹ Diagnoses were confirmed with the Autism Diagnostic Observation Schedule-Module 3 (ADOS-3; Lord et al., 1999) and the Social Communication Questionnaire-Lifetime (SCQ; Rutter, Bailey & Lord 2003). Children with a genetic or metabolic disorder known to cause autistic features, major medical issues, or physical disability were excluded from the sample of children with autism. Children with complex medical histories, psychiatric conditions, developmental delay, first- or second-degree relatives with autism, or autistic symptoms by parent report (SCQ) were excluded from the sample of typically-developing children.

Study 1: Verbal Exchange

Procedure

Participants participated in brief conversations with an adult partner, a research assistant who was blind to group status. Each participant was asked to tell his/her partner about 1) a circumscribed interest or favorite hobby (identified prior to the task through parent report) and 2) a generic topic (siblings, pets, or friends). The two topics were presented in counterbalanced order across participants. Research assistants followed a standard procedure of asking an opening question about the topic and then responding naturally to what the participant said without leading the exchange. If the participant was unresponsive they were asked to initiate no more than two questions beyond the opening one. Each topic was videotaped and abridged to 1 to 3 minutes in length for analysis. Each video clip began with the partner asking the child an opening question about the generic or interest topic, and ended after the child's last utterance in response to this topic, or his or her last utterance within 3 minutes of the partner's opening question, whichever came first. This was to ensure that conversation was sampled in a similar manner for all participants and that conversational features did not surface for extraneous reasons, e.g. boredom in conversations that lasted longer than the standard time. Gaze data was obtained via a lightweight head-mounted eye-tracking device (Model H6, Applied Science Laboratories, Inc., Bedford, MA) worn during the course of the conversation. Participants had full range of movement; a magnetic head tracker was used to correct gaze data for head movement.

Coding of verbal exchange—Conversations were transcribed following the CHAT transcription standard of the Child Language Data Exchange System (CHILDES). Using Computerized Language Analysis from the CHILDES Project, total number of child utterances, total number of experimenter utterances, mean length of utterance, and measures of lexical diversity were calculated to provide data on the global characteristics of the exchange. In addition a comprehensive coding scheme was developed, whereby each participant utterance was coded on a range of pragmatic and linguistic features. Codes related to topic maintenance, level of information, and atypical utterances are reported here.

Participant utterances were coded as follows with respect to topic maintenance. Contingency was operationalized using definitions provided by Tager-Flusberg & Anderson (1991), who considered contingent utterances to be those that maintained the topic of discourse of the adult's prior utterance. Responses, or utterances that immediately followed a question or statement by the partner were coded as *contingent* or *non-contingent*. Elaborations, or child statements that

¹Although in practice some would designate individuals with ASD and average IQ without a history of language delay as having Asperger's Syndrome, the presence of early language delay is not necessary for a diagnosis of Autistic Disorder following DSM-IV criteria. However meeting criteria for Autistic Disorder does preclude a diagnosis of Asperger Syndrome (as elaborated in Tryon, Mayes, Rhodes, & Waldo, 2006). We provide this information to allow for full characterization of our sample, but do not focus on this distinction as it was unrelated to performance on all but one of the variables we examined, described in the results section for Study 1.

were not direct responses to the partner were coded as *contingent*, *self-contingent*, or *non-contingent*. Questions directed to the partner were also coded as *contingent* or *non-contingent*. Given previous findings of more non-contingent utterances in 3- to 7-year-old children with autism than comparison groups (Tager-Flusberg & Anderson, 1991) and of more tangential utterances produced by high-functioning children and adolescents with autism than by typical peers (Volden et al., 2007) we predicted that the HFA group would display fewer contingent responses and contingent elaborations than the comparison group.

Contingent responses were further coded according to the level of information they provided: *appropriate*, *overinformative* or *underinformative*. Since it is conventional to add to the ongoing topic of discourse in a reciprocal conversation the *appropriate* code was applied to contingent responses that allowed the flow of conversation to continue, the *overinformative* code was given to utterances that conveyed excess information to the point of disrupting the back and forth flow of conversation, and the *underinformative* code was applied in cases of yes/no, one word, or other responses that were inadequate in the context of conversation. It was predicted that the HFA group would have fewer utterances with appropriate level of informativity given previous reports of reduced information-adding and topic-extending responses given by children with autism (Capps, Kehres & Sigman, 1998; Tager-Flusberg & Anderson, 1991).

We also coded idiosyncratic language and atypical utterances characteristic of autism. The idiosyncratic use of words and phrases in autism has been noted since the writings of Kanner (1943, as cited in Volden & Lord, 1991) who described the speech of individuals with autism as “literal,” “peculiar and out of place in ordinary conversation” and “irrelevant and metaphorical.” Rutter (1965) described another phenomenon, children with autism who had “invented their own words for things,” also known as neologisms. We developed a coding scheme for the use of conventional words or phrases in unusual ways based on the types of idiosyncratic phrases observed in our data. The types of atypical utterances we coded were: scripted speech, listing, pedantic utterances, unusual word use or phrasing, and illogical utterances. We predicted that these would be more frequently observed in the HFA group than the comparison group, as reported by Capps et al., (1998), Volden & Lord (1991) and Wetherby & Prizant (2000).

Using videotapes in tandem with conversation transcripts, two coders blind to group status double-coded 10 of the conversations (26% of the sample) representing both participant groups. Kappa coefficients of inter-rater agreement were calculated for coding categories with nominal data: response type (0.92), initiation type (0.90), and level of informativity (0.88). Intraclass coefficients were calculated for the binary measure of atypical utterance types: listing (0.93), scripted speech (1.0), atypical word choice (0.98), and unusual content (0.83). Disagreements were discussed until raters reached consensus, and the remaining transcripts were coded by one rater.

Results

Data were analyzed using the t-test (t), unequal variance t-test, Mann-Whitney U test, or Wilcoxon signed-ranks test (T), Pearson’s product-moment correlation (r), Kendall’s rank correlation coefficient (λ) as appropriate given the parametric assumptions of normality and homogeneity of variances and independence of the variables analyzed.

Mean values of all verbal exchange variables, collapsed over topic, are presented in Table 2. Groups did not differ in terms of the overall number of questions or comments addressed to participants by adult partners, the total number of participant utterances, or the ratio of participant to adult utterances. In addition, the groups did not differ with respect to MLU or measures of lexical diversity.

Scores for the domains of interest: contingency, level of information, and atypical utterances were translated into proportion scores. In the results below group differences collapsing over both topics of conversation are presented first, followed by differences by topic. Effect size is reported using Pearson's r which can be computed for both parametric and nonparametric tests (small effect = .1, medium effect = .3, large effect = .5).

Contingency of response and initiation—Across all conversations, the proportion of contingent responses was marginally lower in the HFA than the comparison group, $U=121.5$, $p=.06$, $r=0.31$. Similarly, when elaborations were considered, there were significantly fewer contingent elaborations on the introduced topic in the HFA group than in the comparison group, $U=64$, $p<.01$, $r=0.43$. Participants initiated questions at a very low rate in both groups (less than 5% of all child utterances) and there was no group difference with respect to question contingency.

An examination of topic revealed that for the HFA group, fewer contingent responses, $T=1$, $p<0.05$, $r=0.37$, and fewer contingent elaborations, $T=7.5$, $p<0.05$, $r=0.32$, were produced during the interest topic than during the generic topic. In addition participants with HFA made significantly more self-contingent elaborations that maintained a topic they themselves had introduced during the interest relative to the generic topic, $T=0$, $p<.01$, $r=.44$. There were no significant differences based on topic for the comparison group. Figure 1 shows the proportion of response type by group and topic, while Figure 2 depicts proportion of elaboration type by group and topic.

Level of information provided in contingent responses—Contingent responses were examined further for the level of information they conveyed. Collapsing over topic there were more participant responses at an appropriate level of informativity in the comparison group than in the HFA group, $t(28)=-3.18$, $p<.01$, $r=.52$. Mirroring this, the HFA group gave more responses than the comparison group of two varieties, both those that were underinformative, $U=104.5$, $p<.05$, $r=0.33$, and those that were overinformative, $U=136$, $p=.05$, $r=0.31$. There were no significant effects of topic on the level of information provided for either group.

Atypical utterances and idiosyncratic language use—We examined a summary measure of the proportion of any atypical utterance over all utterances produced. This included scripted speech, listing, pedantic utterances, unusual word use or phrasing, and illogical utterances. This summary measure was higher in the HFA group than the comparison group, $U=36.5$, $p<.001$, $r=0.69$ (see Figure 3 for the distribution of atypical utterances type by group and topic). Three types of atypical utterances: scripted speech, listing, and pedantic phrases, were evidenced only in the HFA group. The individual categories of scripted speech, $U=136$, $p=.05$, $r=0.32$, listing, $U=110.5$, $p<.01$, $r=-0.44$, and unusual word choice or phrasing, $U=102$, $p<.05$, $r=0.38$, were also significantly higher in the HFA group than the comparison group. There was a trend for increased scripted speech by HFA participants in the interest relative to the generic topic, $T=0$, $p=.07$, $r=.29$.

Correlations between conversational performance and participant characteristics—To explore relationships between participant characteristics and measures of topic maintenance, informativity, and atypical utterance use, scores from these domains were correlated with chronological age and the following standardized measures: language level (CELF-4), Performance IQ (WASI), Daily Living Skills and Socialization subscales of the VABS, a measure of autism symptoms obtained by summing the scores of all ADOS-3 items, and a score of Stereotyped Behaviour and Restricted Interest symptoms (henceforth SBRI), obtained by summing the scores from items in the corresponding section (D) of the ADOS-3.

In the HFA group, ADOS-3 total scores (where higher values indicate increased severity) increased as responses conveying an appropriate level of information decreased, $r = -.52$, $p < .05$. In addition, SBRI scores, reflecting stereotyped behaviour and restricted interest symptoms, increased as the proportion of contingent responses, $\lambda = -.38$, $p < .05$, and the proportion of contingent elaborations, $\lambda = -.50$, $p = .01$, decreased. These scores were also positively correlated with the proportion of self-contingent elaborations, $\lambda = .60$, $p = .01$, as well as the summary score of atypical utterances used, $r = .73$, $p < .001$. Relationships between these variables and SBRI scores are shown in Figure 4. For the HFA group there were no relationships between conversational features and age, language level, or PIQ. Finally, we examined whether the presence ($n = 8$) or absence ($n = 12$) of early language delay impacted conversational behaviour in these school-age children with HFA. These subgroups did not differ significantly with respect to MLU, contingency of response or initiation, or proportion of atypical utterances. They did however differ with respect to the proportion of contingent responses where they provided an appropriate amount of information for the Generic topic, HFA + language delay ($M = .49$) HFA – language delay ($M = .79$), $t(18) = -2.184$, $p = .04$, $r = .46$. This comparison was marginally different for the Interest topic as well, $t(18) = -1.85$, $p = .08$, $r = .40$.

In the comparison group, the summary score for atypical utterances produced increased as language level decreased, $r = .57$, $p < .05$.

Discussion

Participants with HFA differed from their typical peers with respect to the three features of verbal exchange examined here. They displayed difficulty with maintaining the topic of conversation via their responses and elaborations, a decreased tendency to convey an appropriate amount of information in contingent responses, and a greater proportion of atypical utterances that disrupted the flow of conversation. Notably these group differences emerged in the context of conversations that were similar with respect to the number of adult and participant utterances, number of turns between partners, and measures of lexical diversity.

The manipulation of topic did not affect the verbal exchange of the comparison group, but did have an impact on the conversational behaviours of the HFA group. When participants with HFA spoke about their CI, relative to a generic topic, they gave significantly fewer responses and elaborations that were contingent upon the topic of conversation. In addition they made significantly more self-contingent elaborations that were not completely novel but were related to a topic they themselves introduced and kept speaking about, creating the feel of a monologue. They also exhibited a trend for more scripted speech in the interest condition. These behaviours seem to stem from the increased knowledge base and practiced scripts individuals with HFA develop around their CIs. Our findings suggest that, for participants with HFA, the high level of interest engendered by their CI increased onesided and stereotyped exchanges rather than motivating them to be more engaged and attentive to their partner. This supports the second hypothesis outlined in the introduction, that speaking about a CI has negative effects on reciprocal conversation.

Further support for the stereotyped and perseverative effect of CIs on conversation comes from our finding that SBRI scores were inversely related with measures of contingency in our HFA sample, and were positively related to self-contingent elaborations and atypical utterances. In other words, those participants who presented more stereotyped behaviour and restricted interest symptoms during the ADOS-3 (conducted a couple of weeks apart from the conversation task) were the same individuals who gave less contingent responses and elaborations, and who produced more monologue-style speech and atypical utterances during conversation. It is particularly notable that the relationship between the severity of an individual's restricted and repetitive interests and the presence of a perseverative and one-sided

conversational style held across tasks that were sampled at different times. This suggests that degree of repetitive interests and one-sided conversational style are stable, trait-like features.

Finally, participants with HFA exhibited a general decrease in responses that provided an appropriate level of information. This difference was not impacted by the topic of conversation nor was it related to SBRI scores; it appears to be independent of an individual's tendency to persevere on a CI. Instead, this feature of conversation seems to be related to overall autism symptomology; participants with higher ADOS-3 total scores produced fewer responses conveying an appropriate level of information.

Next we examine the use of eye gaze during the same conversations. As stated above we were neutral in our predictions of whether group differences would appear in the generic condition. However, with respect to the topic manipulation *within* the autism group, given the reduced reciprocity observed in their verbal exchange during topics of interest, it is possible this would surface as reduced eye contact with the partner in the interest condition relative to the generic condition.

Study 2: Eye gaze during conversation

Participants

Eye-tracking data was available for a subset of participants from the conversation task. Data from 1 participant with HFA was not available due to lack of willingness to wear the eye-tracker, and was not available from 7 participants with HFA and 6 typically-developing participants due to technical error with the eye-tracking software or video recording. This left data that could be analyzed digitally using EYENAL and FixPlot software (Applied Science Laboratories, Inc., Bedford, MA) from twelve participants with HFA (10 boys, 2 girls, mean age = 11;4), and eleven typically-developing participants (9 boys, 2 girls, mean age = 11;0). The groups remained matched for chronological age, gender, language level, and performance IQ. Five of the 12 participants with HFA had a history of early language delay, 7 did not.

Coding of gaze data

During conversation a camera on the eye-tracker headband recorded video from the participant's perspective while gaze data was digitally recorded by EYENAL software. Still images were captured from this video, depicting the adult partner seated across a table. To code for fixation location unique areas of interest (AOIs) were developed for each participant using FixPlot software. AOIs were created for the partner's Face, Body, and Non-partner areas (i.e., all other regions of the room, including the table, walls, the participant's own body). Partners remained seated in the same location at the table throughout the conversation, however AOIs were drawn slightly larger than the relevant areas to compensate for movement that may have occurred during the conversations. Figure 5 shows an example still image of the partner with AOIs superimposed.

The Face and Non-partner AOIs were chosen for primary analysis, as it was expected that typical participants, and possibly participants with autism as well, would spend a significant amount of time looking to their partner's face during conversation. We expected that the comparison group would look more to their partner during the interest topic relative to the generic topic. The HFA group was expected to follow the same pattern if the interest topic motivated them to be more engaged and reciprocal with their partner. Alternatively, if speaking about a CI led individuals with autism to be more one-sided in conversation, this topic may engender more looks to Non-partner regions.

Results

Eyenal output provided the proportion of time spent looking to each AOI. Data was submitted to 2 group (HFA, typically developing) $\times$ 2 topic (generic, interest) mixed ANOVAs.

Looks to partner's face—The mean proportion of time spent looking to the partner's face during the generic topic was 30% of the time for the HFA group and 38% of the time for the TYP group. During the interest topic this increased to approximately 33% for the HFA group and 43% of the time for the TYP group. There was a significant main effect of topic, $F(1,21) = 7.25, p < .05, r = .51$, due to increased time spent fixating the partner's face during the interest topic relative to the generic topic. There was no main effect of group, $F(1,21) = .60, p = .45, r = .17$. There was no interaction between group and condition, $F(1,21) = .44, p = .52, r = .14$.² Figure 6 shows time spent looking to the Face AOI by topic and group. In addition we examined whether amount of time spent fixating the Face AOI differed between HFA participants with ($n=5$) and without language delay ($n=7$); there was no significant difference for either topic.

Looks to non-partner areas—Mirroring the findings for the Face AOI, there was a significant main effect of topic, $F(1,21) = 10.31, p < .01, r = .57$, in which looks to the Non-partner areas decreased during the interest topic, relative to the generic topic. Again there was no main effect of group, $F(1,21) = 1.03, p = .32, r = .22$. Finally there was no significant interaction, $F(1,21) = .80, p = .38, r = .19$.

Correlations between gaze behaviour and participant characteristics—

Correlations between ADOS total scores corrected for an eye gaze item (ADOS-3 total raw scores with item B1 “unusual eye-contact” excluded) and the percentage of time spent fixating the Face AOI were computed for the HFA group. For the generic topic there was an inverse relationship between time spent looking at the Face AOI and ADOS total scores ($r = -.68, p < .05$), such that participants with HFA who looked less to their partner's face displayed more autism symptoms. There was a non-significant trend in the same direction for the interest topic ($r = -.52, p = .08$). In contrast there were no significant relationships between time spent fixating the Face AOI and age, language level, and PIQ for the HFA group. For the TYP group there were no significant relationships between gaze behaviour and age, language level, or PIQ.

Finally, we examined whether gaze behaviour, specifically the percentage of time spent fixating the Face AOI, was related to an individual's verbal exchange behaviour. No significant relationships were found for the TYP group. In the HFA group, however, time spent fixating the Face AOI was negatively related to the proportion of atypical utterances produced, after partialling out autism severity (ADOS-3 total scores). In other words, HFA participants who looked more to their partner's face produced less atypical utterances, and this was not explained by both factors being linked to the third variable of autism severity. This relationship was significant for the Interest topic ($r = -.63, p = .04$) and marginal for the Generic topic ($r = -.58, p = .06$).

Discussion

We found no significant group difference between school-age children with high-functioning autism and their typically-developing peers in time spent looking to the partner's face during conversation. This result is consistent with a growing body of autism studies that have failed to find significant group differences in visual attention to people in naturalistic scenes or situations. The absence of group differences in time spent viewing social stimuli have been

²We also analysed data on the mean duration of fixations to the Face region, which did not differ by topic $F(1,21) = 1.41, p = .25, r = .25$, or group $F(1,21) = .07, p = .80, r = .06$. The percent of fixation count to the Face region was marginally higher for the interest rather than generic topic $F(1,21) = 4.09, p = .056, r = .40$ but there was no group difference in this variable either $F(1,21) = .81, p = .38, r = .19$.

found in adolescents with autism and language delay while engaged in face-to-face interaction (García-Pérez, et al., 2007; Mirenda, Donnellan, & Yoder, 1983) or while watching videos of social events (Norbury, et al., 2009), and in adolescents and adults with autism and normal language while viewing static scenes containing people (Fletcher-Watson et al., 2009). The lack of a significant group difference in our study was due to the striking individual differences evidenced in both groups, depicted in Figure 5, with respect to time spent viewing different regions of the live scene. As mentioned above the mean proportion of time spent looking to the partner's face during the generic topic was 30% for the HFA group and 38% for the TYP group. During the interest topic this increased to approximately 33% for the HFA group and 43% for the TYP group. These rates of looking to a partner during face-to-face conversation align very closely with previous reports: Levine & Sutton-Smith (1973) found that typically-developing 9- to 12-year-olds looked to their partner's face about 40% of time when speaking to an adult, and García-Pérez, Lee, & Hobson (2007) found that adolescents with autism and adolescents with intellectual delays did so 30%–40% of the time. As in most previous studies examining the use of social gaze (Dalton, et al., 2005; Fletcher-Watson, et al., 2009; Klin, et al., 2002; Norbury, et al., 2009; Spezio, Huang, Castelli, & Adolphs, 2007) we used proportion of fixation time to social stimuli, in this case the partner's face, as our primary measure. Yet, despite similarities in percent time spent looking to the partner's face during conversation it is possible that more fine-grained aspects of gaze behaviour may differ between groups. In particular, the synchrony and subtle coordination of gaze with a conversational partner may be crucial to our subjective perception of eye contact. These dynamic factors of gaze behaviour should be investigated in future work.

We found a significant main effect of topic, whereby both groups looked more to their partner's face during the interest topic relative to the generic topic. This adds to findings of qualitatively similar patterns of visual attention across experimental conditions in groups of participants with HFA and those with typical development (Fletcher-Watson, et al., 2009; New, et al., 2010; Vivanti, Nadig, Ozonoff, & Rogers, 2008). When considered in isolation, and given our initial predictions, increased looking to the partner's face could reflect increased engagement with the partner while speaking about a topic of special interest. This is in fact what take the finding to reflect for the comparison group. We will return to how this finding fits with the topic effect on verbal exchange for the HFA group below. With respect to the gaze finding itself, it is important to note that the time spent looking at a region does not necessarily capture the function of visual attention, which may have differed between groups despite equivalent looking times. Our analysis does not allow for the exploration of differences in the quality of looks to the partner, or in the partner's perception of the gaze as reciprocal in nature. The qualitative way gaze is used may be a more meaningful measure of eye *contact* than measures of duration of visual attention alone, as suggested by Mirenda, Donnellan & Yoder (1983) and by Hobson & Hobson (2007). For instance, García-Pérez, Lee & Hobson (2007) collected subjective but reliable ratings of emotional engagement during conversation with a partner. Their participants with autism were rated to be less engaged, though they looked to their partner's face for a similar amount of time as the comparison group.

General Discussion

We investigated two modes of communication, verbal exchange and eye gaze, during face-to-face conversation on a generic topic and a topic of special interest: a circumscribed interest in the case of participants with HFA, or a favorite hobby for typically-developing participants. In their verbal exchanges HFA group displayed difficulties with topic maintenance (e.g. contingency of response and elaboration) and with providing an appropriate amount of information in responses, as well as increased production of atypical utterances relative to the comparison group. When eye gaze to the partner's face was examined, there was no significant

difference between groups and a similar spread of individual differences was observed within each group.

A primary aim of this study was to explore the effect of motivation on conversational behaviour, and to determine whether speaking about a CI would engender more reciprocal conversational behaviour in participants with HFA via its potential for motivation, or if it would negatively impact reciprocal exchange due to the consuming and perseverative nature of CIs. On the surface, the topic manipulation appeared to have opposing effects on the verbal exchange and the use of eye gaze. Whereas the interest topic had negative effects on reciprocal verbal exchange for participants with HFA (e.g. worse contingency of response and elaboration, increased self-contingent utterances, and a trend for increased use of atypical utterances relative to the generic condition), it engendered greater looking time to the partner's face in both groups. How can these findings be reconciled?

Our interpretation is that the effect of speaking about a CI for children with HFA did not increase engagement with the partner and was instead detrimental to reciprocal exchange, resulting in more one-sided, stereotyped, and monologue-like speech for many HFA participants. Given this, our study has much in common with a pilot study in the literature. Mirenda, Donnellan & Yoder (1983) explored eye gaze between children and adolescents with autism or typical development (four in each group) and an adult partner under two conditions: a monologue interaction, where participants told a story or recalled an event while the adult remained passive and responded nonverbally, and a dialogue interaction where the adult asked questions about a variety of topics. Though effects did not reach significance due to the small number of participants, participants with autism tended to look more to their partner's face during monologue interactions, while the reverse was observed in the comparison group. Our finding with a larger and better-characterized sample corroborates this initial report of increased looking to the partner's face in a monologue setting -- effectively what HFA participants transformed the interest topic into. Why would there be increased looking to the partner if this is not due to increased reciprocity or engagement? One possibility is that speaking about a CI is a highly practiced and repetitive activity for individuals with HFA and has become an automated process, thus freeing up cognitive resources for other purposes such as attending to a conversational partner who is talking. These looks to the partner may have had more of an orienting function (in response to sound or movement on the part of the partner), as designated by Hobson & Hobson (2007), than a sharing function that is reciprocal in nature. To elucidate these findings future work should examine the quality of looks via reliable subjective ratings, as well as the timing of visual attention with respect to a conversational partner's speech and movements.

Consequently, the main effect of CI on conversational exchange in participants with HFA was reduced reciprocity in verbal exchange and an increase in stereotyped speech and strings of self-contingent utterances with the quality of monologue, accompanied by an increase in what we take to be non-reciprocal gaze towards the partner's face. It is plausible that impaired executive control, and inhibition mechanisms in particular, contribute to the perseverative effects of a CI on conversation. The role of executive functions in communicative contexts should be explored in future research on autism, as they have been found to play an important role in communicative perspective-taking in typical development. In a communication task where visual perspectives differed, Nilsen & Graham (2009) found children's non-egocentric comprehension of object descriptions to be significantly related to inhibition abilities, but not to working memory or cognitive flexibility. These findings suggest that in young typically-developing children increasing inhibition abilities allow for the consideration of a conversational partner's perspective via inhibition of one's own perspective. In autism however Lopez, Lincoln, Ozonoff & Lai (2005) demonstrated that a profile of both executive function strengths (working memory and response inhibition) and deficits (cognitive flexibility) was

related to the severity of an individual's restricted and repetitive behaviours. It may be that multidimensional executive function profiles are implicated in both the individual differences observed with respect to CIs in autism and their associated non-reciprocal effects on conversation.

The data presented here indicates that CIs have negative repercussions for the communication of school-age children with HFA, as opposed to the positive effects observed previously for social communication in young children with autism (Baker, Koegel & Koegel, 1998; Boyd et al., 2007; Vismara & Lyons, 2007). It is important to note that CIs surface differently at different levels of development; for our participants they were favorite topics to discuss and collect information on, whereas for the young minimally-verbal children in the cited intervention studies they were represented by preferred objects. Further research is needed to understand the impact of CIs on social communication across development on the autism spectrum, in both children with autism and concurrent language and developmental delays and in high-functioning children with PDD-NOS who present with fewer symptoms than those tested here. This line of study will have important implications for treatment, in determining whether the incorporation of CIs in an intervention plan will be beneficial for a specific child with ASD.

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Figure 1.
Proportion of response types by group and topic.

Figure 2.
Proportion of elaboration types by group and topic.

Figure 3.
Occurrence of atypical utterance types by group and topic. Error bars indicate standard error.

Figure 4. Relationship between Stereotyped Behavior and Restricted Interest scores (higher values indicate greater symptoms) and (a) proportion of contingent responses and contingent elaborations (b) proportion of self-contingent elaborations and atypical utterances.

Figure 5. Sample still image from participant's view (a) with AOIs superimposed and (b) with fixations from a typically-developing participant, interest topic plotted

Figure 6.
Percent time spent looking at Partner's face during each topic.

Table 1

Participant Characteristics

Group			
	Typically developing (n=17) <i>Mean (SD)</i>	High-functioning autism (n=20) <i>Mean (SD)</i>	p
Chronological Age	10;10 (1;5)	11;0 (1;11)	.73
Language (CELF-IV Core)	112.7 (12)	107.1 (14)	.21
PIQ (WASI)	112.5 (14)	106.5 (17)	.25
Gender	76 % male	90 % male	.25
VABS II Socialization	101.3 (8)	61.0 (7)	.00
VABS II Daily Living	101.7 (9)	67.7(8)	.00
SCQ	2.3 (3)	26.4 (6)	.00
ADOS-3 algorithm	N/A	13.7 (4)	N/A
ADOS-3 Stereotyped Behavior and Restricted Interest	N/A	3.6 (2)	N/A

Note. There were no significant differences between groups with respect to CA, language level, PIQ, or gender.

Table 2

Global and pragmatic characteristics of conversations, collapsed over topic

Measure	Typically-developing		High-functioning autism	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Number of adult utterances	10.90	1.11	12.00	1.24
Number of participant utterances	18.64	1.18	19.07	1.63
Proportion of participant to adult utterances	1.99	.21	2.03	.33
MLU	8.55	2.92	7.32	2.83
Type token ratio	.56	.05	.61	.10
Number of types	91.76	24.12	85.20	39.45
Ratio response/all utterances	.53	.18	.59	.21
Ratio elaboration/all utterances	.45	.22	.39	.23
Ratio question/all utterances	.02	.04	.03	.06
Proportion of contingent responses	.99	.01	.96	.01
Proportion of contingent responses conveying appropriate level of information	.80 *	.03	.61 *	.05
Proportion of contingent elaborations	.92 *	.04	.64 *	.08
Proportion of contingent questions	.83 (n=3)	.17	.90 (n=5)	.10

Note. * indicates a significant group difference at the $p < .05$ level