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When do children with Autism Spectrum Disorder take common ground into account during communication?

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Abstract

One feature of autism spectrum disorder (ASD) is a deficit in verbal reference production; i.e., providing an appropriate amount of verbal information for the listener to refer to things, people, and events. However, very few studies have manipulated whether individuals with ASD can take a speaker's perspective in order to interpret verbal reference. A critical limitation of all interpretation studies is that comprehension of another's verbal reference required the participant to represent only the other's visual perspective. Yet, many everyday interpretations of verbal reference require knowledge of social perspective (i.e., a consideration of which experiences one has shared with which interlocutor).

We investigated whether 22 5;0- to 7;11-year-old children with ASD and 22 well-matched typically developing (TD) children used social perspective to comprehend (Study 1) and produce (Study 2) verbal reference. Social perspective-taking was manipulated by having children collaboratively complete activities with one of two interlocutors such that for a given activity, one interlocutor was Knowledgeable and one was Naïve. Study 1 found no between-group differences for the interpretation of ambiguous references based on social perspective. In Study 2, when producing referring terms, the ASD group made modifications based on listener needs, but this effect was significantly stronger in the TD group. Overall, the findings suggest that high-functioning children with ASD know with which interlocutor they have previously shared a given experience and can take this information into account to steer verbal reference. Nonetheless, they show clear performance limitations in this regard relative to well-matched controls.

Keywords: Autism, Children, Reference, Common Ground, Verbal Social Communication, Production, Comprehension.

Lay summary (Max = 80 words)

No-one had studied if young children with Autism Spectrum Disorder (ASD) could take into account previous collaboration with particular conversation partners to drive how well they communicate with others. In both their language understanding and spoken language we found that five to seven-year-olds with ASD were able to consider what they had previously shared with the conversation partner. However, they were impaired when compared to typically-developing children in the degree to which they tailored their spoken language for a specific listener.

Introduction

The diagnostic criteria for Autism Spectrum Disorder (ASD) include deficits in verbal social communication (APA, DSM-5, 2013). A distinctive characteristic of verbal social communication among individuals with ASD is an impairment in 'audience design' (Volden, 2002), the ability to provide an appropriate amount of information for the listener's informational needs (Clark & Marshall, 1981). For example, if a speaker wants a particular loaf at the bakery, then a complex referring expression such as 'the biggest loaf' could be appropriately informative, whereas requesting 'the bread' would be under-informative. However, at dinner with only one loaf of bread, asking for 'the big loaf' would be over-informative. A deficit in audience design is likely to contribute to difficulties with peer popularity (see e.g. Rubin, 1972; Gottman, Gonso & Rassmussen 1975) and reciprocal conversation (e.g. Fine, Bartolucci, Szatmari & Ginsberg, 1994). Use of under-informative referring expressions, in particular, leads to breakdowns in the ability to make successful requests (e.g. Matthews, Lieven & Tomasello, 2007).

The degree to which an expression is appropriate depends on consideration of the knowledge shared between speaker and listener, referred to as 'common ground' (Clark, 1996). Moll and Kadipasaoglu (2013) distinguish between visual common ground, which requires a consideration of whether the interlocutor can see particular items, and social common ground, which requires a consideration of the experiences the individual has previously shared with the interlocutor. They argue that visual perspective-taking may not require an in-depth consideration of the contents of the interlocutor's mental states; any interlocutor positioned behind a barrier will not be able to see a particular object. In contrast, social common ground is interlocutor-specific. Prior joint engagement and collaboration are argued to be crucial in determining social common ground for typically-developing (TD) children (Kern & Moll, 2017; Rakoczy, 2017; Tomasello, Carpenter, Call, Behne & Moll, 2005). For example, if a speaker and interlocutor have been collaborating by using a specific hammer to put a toy together, then the simple referring expression in 'Pass <u>the hammer</u>' is appropriately informative even when other hammers are visually co-present (e.g. Schmerse, Lieven & Tomasello, 2015).

Compared to TD groups which are well-matched for chronological age, non-verbal IQ and formal language (syntax or vocabulary), ASD groups usually under-perform in the production of appropriately informative referring expressions during narrative tasks (Colle et al., 2008; Suh et al., 2014; Banney, Harper-Hill & Arnott, 2015; Arnold, Bennetto & Diehl, 2009). The same has been found in production studies that have used interactive experimental manipulations of the participant and interlocutor's shared visual perspective (e.g. Nadig, Vivanti & Ozonoff, 2009; Fukumura, 2016; Dahlgren & Dahlgren Sandberg, 2008; Volden Mulcahy & Holdgrafer, 1997; Nadig, Seth & Sassoon, 2015). That said, one study which used a very simple narrative elicitation task (Kuijper, Hartman & Hendriks, 2015) found no differences between children and adolescents with ASD and TD controls. Moreover, some studies have found – alongside evidence of impairments relative to controls – indications that children and adolescents with ASD show an awareness of listener information needs (Makinen et al., 2014; Arnold et al., 2009; Norbury & Bishop, 2003).

In contrast to research on the production of contextually-appropriate verbal reference in ASD, there are very few studies manipulating the role of speaker perspective on the interpretation of verbal reference, which have included typical controls. In a ‘Director Task’ where speaker and listener visual perspectives matched (common ground condition) or were disparate (privileged ground condition), Begeer, Malle, Nieuwland and Keysar (2010) and Santiesteban, Shah, White, Bird and Heyes (2015) found no differences in either accuracy, response latency or gaze fixations for adults with ASD relative to typical controls. Schuh, Eigsti & Mirman (2016) also found no differences between 13-year-olds with ASD and TD controls on accuracy measures in a referential communication task requiring participants to recall which referents were known to the speaker. The ASD group made more gaze fixations to the objects unknown to the speaker (privileged ground condition) than did the TD controls, when the task involved a high working memory burden (a larger number of shapes). Therefore, it may be that individuals with ASD possess the necessary socio-cognitive competence to use common ground to interpret verbal reference but fail to consistently apply this competence/knowledge depending on extraneous factors which contribute to task difficulty.

That said, it would be surprising if individuals with ASD really possessed an underlying conceptual competence in verbal reference interpretation per se, because this ability is usually considered to rely on the Theory of Mind (ToM)/mentalising ability that is known to be impaired in ASD (e.g. White, Hill, Happé & Frith, 2009). There are several reasons to be cautious when drawing conclusions from the findings of existing studies of verbal reference interpretation in ASD. First, all studies of verbal reference interpretation by individuals with ASD have only included adolescents or adults. Therefore, individuals with ASD might ‘outgrow’ an initial impairment in the ability to take common ground into account while interpreting verbal reference. Alternatively, it might be that older adolescents and adults with ASD employ alternative, compensatory strategies to “hack out” solutions to tests of verbal reference interpretation, in a manner similar to that reported for classic ToM tasks (e.g., Frith, Morton & Leslie, 1991). If, however, young children with ASD can in principle demonstrate the ability to take the knowledge-state of an interlocutor into account to drive verbal reference interpretation or production, then arguments regarding maturation or compensatory strategies are difficult to sustain.

Second, previous studies only assessed the interpretation of verbal reference in the context of level one visual perspective taking, namely whether the interlocutor can see the referential alternative[1]. This is problematic, because level one visual perspective taking could be carried out by simply using a non-mentalising heuristic, such as following the physical line of gaze without giving any in-depth consideration to the content of the gazer’s mind. Evidence supporting this suggestion comes from Sanstieban et al.’s (2013) study, that found no differences for either group between the experimental and a control condition, in which the interlocutor was replaced with a camera. Therefore, the results from the studies of Begeer et al. (2010), Sanstieban et al. (2015) and the low working memory condition in Schuh et al., (2016) cannot be taken as definitive evidence that an ability to use personal common ground to interpret verbal reference is spared in ASD. To test this, we need to investigate whether individuals with ASD can interpret verbal reference by taking into account social common ground, i.e. by considering which previous joint action they have shared with which particular interlocutor (Rakoczy, 2017; Kern & Moll, 2017).

We therefore carried out the first study to manipulate social perspective-taking in the context of verbal reference production or interpretation by children with ASD. Indeed, ours is the first study of verbal reference interpretation by children with ASD. The mean age of our sample is also younger than any study which has investigated verbal reference production in ASD; we included children with ASD aged 5;0 to 7;11-years and TD children matched for age, non-verbal IQ, and formal language. For our interpretation experiment (Experiment 1) we adapted a social common ground paradigm originally developed for TD children by Liebal, Behne, Carpenter and Tomasello (2009). For each experimental trial, each participant first collaborated in one activity (e.g. constructing an electric circuit) with one experimenter, who then left the room ostensibly to find a missing object (here: a battery) needed to complete that activity. Each participant then collaborated in another activity (e.g. putting together a remote-controlled car) with another experimenter, who then also left the room ostensibly to find a missing object – the same missing object – needed to complete that activity. For the final component of each trial, one of the two experimenters (the Requester) returned to the room, offered the participant the missing object and said "Here it is! Now you can do it". The measure was whether the participant inserted the object into the activity in which the participant had engaged with the Requester. To control for the possibility that children might select the correct referent using a heuristic such as 'go to the activity the person making the request was co-present with' (e.g. O'Neill, 2005) we also had a co-presence only control condition.

Our verbal reference production experiment (Experiment 2) was elicited by asking the same children to re-tell how to construct toys, that they had made as part of the interpretation experiment, in two within-subject conditions. One required the participant to re-tell to the adult who had completed the task with them (Knowledgeable Listener). The other condition required each participant to explain the toy construction to an adult who had not been present for this activity (Naïve Listener). If participants engaged in audience design, they should use complex referring expressions (e.g. 'the long elastic band') for the Naïve Listener but simple referring expressions (e.g. 'the elastic band') for the Knowledgeable Listener.

If autistic difficulties with audience design found in naturalistic interaction derive primarily from a competence deficit in the ability to take social common ground into account, this would predict that our sample of children with ASD should not differ from chance in our interpretation experiment. A competence deficit account would also predict no differences between the Knowledgeable and Naïve conditions in the production experiment, since this production measure specifically assesses whether participants tailor their selection of referring expressions based on shared knowledge

If, however, naturalistic audience design difficulties are primarily a performance issue, this would allow for above-chance performance in the ASD group in the interpretation experiment and a difference between the Knowledgeable and Naïve conditions in production. Importantly, however, this account would predict an interaction whereby ASD children should show a lesser distinction between the two conditions than would the TD children, indicating a reduced ability to demonstrate their competence.

Experiment 1: Using social common ground to interpret referring expressions.

Methods

Participants. Twenty-two TD children were recruited through a developmental lab database and mainstream schools. Eleven children with ASD attended specialist provisions for children with ASD. The remaining children with ASD were recruited through parent support groups. When recruiting children with ASD, parents and teachers were told that the inclusion criteria included verbal fluency and knowledge of colour and size adjectives. TD and ASD children were matched on chronological age, formal language and non-verbal IQ. To assess formal language, we carried out both receptive (the Sentence Structures sub-test) and expressive language (the Formulated Sentences sub-test) measures from the Clinical Evaluation of Language Fundamentals® - Fifth Edition (CELF®-5, Wiig, Semel & Secord, 2013). Non-verbal IQ was assessed using the Pattern Construction and Matrices tasks from the British Ability

Scales (BAS, Elliot & Smith, 2011). Children in the ASD group had been diagnosed either by a clinical psychologist or a paediatrician. Parents of children in both groups completed the Social Responsiveness Scale (SRS, Constantino & Gruber, 2005). Two children with ASD were tested but excluded because their SRS T-scores were below the clinical cut-off and two TD children were tested but excluded because they scored above this threshold. The demographics for the final sample are shown in Table 1 below, which also includes the scaled scores for the CELF subtests, the average t-score for non-verbal IQ and between-groups differences for tests of First Order Theory of Mind and Advanced Theory of Mind tests (see table legend and also supplementary materials).

Table 1. Means (SD in brackets) for participant characteristics

	ASD (n = 22; 18 male)	TD (n = 22; 18 male)		
	Mean (SD)	Mean (SD)	p	d
Chronological Age in Months	78.86 (11.46)	78.77 (11.19)	.98	0.01
Sentence Comprehension CELF®-5 Scaled Score	10.64 (2.82)	10.05 (1.81)	.41	0.25
Formulated Sentences CELF®-5 Scaled Score	11.14 (3.20)	11.50 (1.87)	.65	0.14
Non-verbal IQ: British Ability Scale T-score[1]	48.59 (10.02)	50.30 (8.93)	.54	0.18
Social Responsiveness Scale T-score	82.86 (9.14)	45.38 (6.14)	<.001	4.81
Theory of Mind First order[3]: max score = 2.0	1.68 (0.65)	1.95 (0.21)	.07	0.56
Theory of Mind 2nd order[4]: max score = 2.0	1.05 (0.9)	1.5 (0.67)	.06	0.50
Theory of Mind Advanced[5]: max score = 4.0	0.18 (0.40)	1.09 (1.19)	.002	1.03

1..This is the mean T score of the 'Pattern Construction' (visuo-spatial pattern matching) and the 'Matrices' (non-verbal fluid reasoning ability) sub-tests of the British Ability Scales. 3. This is the combined score of *'Contents False Belief (Wellman & Liu, 2004; Perner, Leekam & Wimmer, 1987) and the 'Change of location'* (Baron-Cohen, Leslie & Frith, 1985). 4. From Coull, Leekam & Bennett, 2006 – see supplementary materials. 5. *Two of Happe's (1994) 'Strange Stories items ('Kittens' and 'Double bluff') with vocabulary adapted for* younger children – see supplementary materials.

Overall procedure. The Experiment 1 trials were presented as ‘breaks’ from the standardised (non-verbal IQ and formal language) and ToM tests, and were interspersed between them. Each trial (experimental and control) involved one pair of activities requiring a unique common item to enable completion. There were six pairs of activities in total (see Table 2). Each participant completed four experimental trials and two control trials. The six activity pairs were counterbalanced across participants to appear as control trials on an even number of occasions. At the end of the experiment, to verify that participants could remember with whom they shared social common ground, each child was asked to tell either a parent or teacher which activities they had completed with which experimenter. All children successfully remembered this.

Procedure. For each trial (for both experimental and control trials), the child first engaged in constructing one activity (e.g. putting together the piece of wood for a slingshot) and then engaged in the construction of a different activity (e.g. folding and gluing a paper woodpecker). Each construction was completed jointly with one experimenter in the absence of the other experimenter. At the end of each construction activity, the experimenter with whom the child was constructing the activity declared that a key item was missing (here: an elastic band) and left the room to find it. The two experimenters were never in the room at the same time during both control and experimental trials.

Table 2: Construction activity pairs and common missing items (comprehension measure)

Activity Pair	Activities	Key ‘missing’/common item
1	Electric circuit Battery operated toy car	Battery
2	Paper aeroplane Certificate	Glue
3	Tumbling bunny Marble run	Marble
4	Woodpecker	Elastic Band

	Slingshot	
5	Telephone Flying fish	String
6	Spinning bird Blow fish	Straw

For both experimental and control trials, one experimenter ('Requester') returned to the room and stood in a position equidistant to each activity, offering the child an object (e.g. an elastic band) saying *'Here it is. Now you can do it'*. The experimenter only looked between the child and the object (e.g. the elastic band) until the child inserted it in an activity. The visual status of the two activities was equated for both child and the Requester during the request (e.g. both activities occluded in opaque boxes).

In the interaction between Requester and participant prior to the test trial request, the Requester had only seen one of the two activities. Thus, if the Requester had previously (i.e. prior to leaving the room) only seen the slingshot (and not the woodpecker), the slingshot was designated the 'target' and the woodpecker the 'foil' for that trial. If a child asked for clarification, the Requester's responses were scripted.

For both experimental and control trials, we counterbalanced within and across participants which of the two experimenters was the Requester, whether the target was located to the child's right or left and whether the activity associated with Requester was the most recently completed one for the child. We also counterbalanced across participants the order of the activities, which activity of a pair was the target, and whether an activity was assigned to the experimental or control condition.

In the experimental trials, the target activity (e.g. slingshot) had been co-constructed with the Requester and the foil activity (e.g. woodpecker) had been co-constructed with the other experimenter. In the control trials, in contrast, the target and foil activities were both completed with the non-requesting experimenter one after the other (e.g. non-requesting E constructs telephone, leaves room to find string, returns having failed to locate string with materials for ‘flying bird, leaves room to look again for string). Importantly, in the control trials, the Requester had not interacted with the target construction activity. Rather, they had entered the room in the absence of the non-requesting experimenter and merely sat next to either the first or second construction activity (counterbalanced) whilst completing a puzzle with the child. The Requester then left the room, before later returning with the missing item. In these control trials the target was the construction activity which the Requester had sat next to. Both control trials were carried out after all experimental trials were completed.

Scoring

In both experimental and control trials, a score of 1 was awarded for selection of the target activity (i.e. associated with the Requester) and a score of 0 was awarded for selection of the foil. As there were four trials in the experimental condition, the maximum raw score per child was 4. Inter-coder agreement for the interpretation experiment was 100% for both experimental and control trials.

Bayesian analyses

According to Jeffreys’ (1961), Bayes factors (BF_{10}) > 3 provide firm evidence for the alternative hypothesis and values under 1 provide evidence for the null (with values < 0.33 providing firm evidence). A BF_{10} of 3 suggests the alternative hypothesis is three times more likely to be true than the null hypothesis.

Results

Co-presence only control trials. The proportion of times that the co-present activity was selected in the control trials did not differ between the ASD (M = 0.39, SD = 0.31) and TD (M = 0.52, SD = 0.29) groups, $t(42) = 1.52$, $p = .14$, $d = 0.47$, $BF_{10} = 0.74$. This is important because it indicates that co-presence alone is insufficient for children in either group to interpret ambiguous reference.

Experimental trials. For the experimental there was no significant between-group difference in the proportion of trials on which children chose the activity that corresponded to the one they had undertaken with the experimenter making the ambiguous request (ASD: M = .85, SD = 0.23; TD: M = .94, SD = 0.15), $t(42) = -1.56$, $p = .13$, $d = 0.47$, $BF_{10} = 0.78$). Thus, the two groups did not differ from one another in terms of the likelihood that participants would correctly interpret ambiguous verbal reference by selecting the activity associated with a specific interlocutor, namely the interlocutor with whom they had shared that particular activity. Importantly, both groups showed above-chance performance in this experimental condition (ASD group: $t(22) = 7.28$, $p < .001$; TD group: $t(22) = 13.59$, $p < .001$).

Experiment 2: Do children with ASD use audience design in their selection of referring terms?

Participants. Participants were the same as for Experiment 1.

Relationship between Experiments 1 & 2. Four construction activities from Experiment 1, namely ‘electric circuit’, ‘tumbling bunny’, telephone’ and ‘woodpecker’ were used in the production task. Experiment 2 trials always followed the Experiment 1 trial that involved the relevant construction activity. Thus, for example, immediately after engaging in the 'telephone' activity as part of the interpretation study, the child was asked to tell the addressee how to construct the telephone for the production study.

Design. Both groups participated in two within-subject conditions. In the Knowledgeable condition, each participant explained how to construct a toy to the experimenter with whom s/he had made a toy. In the Naïve condition each participant explained how to construct a toy to the experimenter who had not been present during the activity. Two construction activities were re-told in each condition (counterbalanced), with three target (binary-coded) referents for each, resulting in a possible raw score of 6 per condition (see Table 3). Both experimenters were Knowledgeable for two activities and Naïve for the other two activities for each participant.

Table 3: List of referents and their competitors (production measure)

Activity	Referent	Target	Distractor	Total referents
Electric Circuit	Wires	White (with clips)	Black (no clips)	3 (colour, size, colour)
	Battery	Small (fits)	Big (does not fit)	
	Battery Holder	Black (works)	Yellow (broken)	
Tumbling Bunny	Bunny	Big	(Too) Small	3 (size, size, length)
	Marbles	Small	(Too) Big	
	Ramp	Long	(Too) Short	
Telephone	Cups	White (pencil will go through)	Pink (solid-pencil will not go through)	3 (colour, size, length)
	Blu-tac	Big	(Too) Small	
	String	Long	(Too) Short	
Woodpecker	Woodpecker	Green (on card)	White (on paper)	3 (colour, size, length)
	Sellotape	Small (sticky)	Big (with fluff on, will not stick)	
	Elastic Band	Long	(Too) Short	

Procedure: Each child instructed how to construct an overall total of four toys. During the shared experience phase for each Experiment 1 activity, the experimenter who constructed each toy with the child referred to each Experiment 2 target referent and its distractor (e.g. 'we have to use the black battery holder because the yellow one is broken', showing the child the broken item) as they constructed the given toy. For the activities which were used in the production study, one experimenter then told the child that the other experimenter (addressee) would write down what the child said and then use those notes to make a replica toy that could be taken home by the child.

To avoid the use of gestures, children provided instructions via a web-cam, whereby the child could see the addressee, but it was explained that the addressee could not see the child. Simple pictures were provided to remind the child of the steps required in the activity. These pictures were not visible to the addressee, who sat in a separate room. Both the addressee and the child could see (for each activity) three items (e.g. cup, blu-tac, string) which had referential alternatives.

Each mention of a target referent (e.g. cup, blu-tac, string) was coded as follows. Use of complex referring (e.g. 'the small battery'; 'the battery that fits') received a score of 1. Usage of a simple noun phrase (e.g. 'the battery'), a pronoun ('it') or complete omission was scored as zero. The dependent variable was the proportion of referring expressions which were complex. As there were a total of six referents in each condition (three for each construction activity) the maximum raw score for each condition was six. All uses of verbal reference during the instruction task were transcribed and coded by the first author. Eighteen per cent of the data was also transcribed and coded by an independent rater, who was blind to each child's diagnostic status, with strong agreement between the coders (Cohen's k = .95).

Post-test vocabulary check: On completion of testing, children were asked to describe how items differed (e.g. size and colour names). All children were able to use these terms accurately.

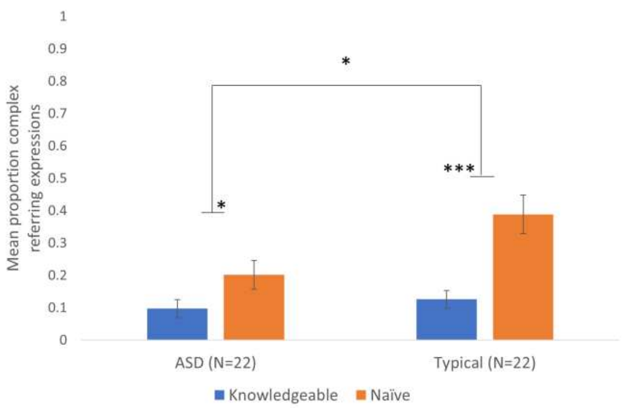
Results

To examine the extent to which children engaged in audience design during production, the mean proportion of complex referring expressions used in the Knowledgeable and Naïve listener conditions was examined (see Figure 1). For context, a proportion score of one in the Naïve Listener condition combined with a proportion score of zero in the Knowledgeable Listener condition would indicate that participants were tailoring their use of verbal reference perfectly to the audience (listener) informational needs.

A mixed 2 (Group: TD/ASD) × 2 (Listener Knowledge: Knowledgeable/Naïve) ANOVA was conducted to compare the mean proportion of complex referring terms used. A significant main effect of Listener Knowledge reflected the use of more complex referring terms with a Naïve than a Knowledgeable listener across groups ($F(1,42) = 30.55$, $p = <.001$, η_p^2=.42 $BF_{10} = 1.40$). The main effect of Group was marginally significant ($F(1, 42) = 3.66$, $p = .063$, η_p^2=.08 $BF_{10} = 1.40$), reflecting less use of complex referring terms among ASD than comparison participants across conditions. More importantly, the Group × Listener Knowledge interaction effect was significant ($F(1, 42) = 6.1$, $p = .02$, η_p^2=.13, $BF_{10} = 3.37$). The TD children showed a significant difference between conditions ($t(21) = 5.41$, $p = <.001$, $d = 1.19$, $BF_{10} = 1031$), indicative of audience design. Importantly, the difference across conditions was also significant for the ASD group ($t(21) = 2.27$, $p = .03$, $d = 0.57$, $BF_{10} = 1.83$,), suggesting that they were aware of their listener's informational needs and made attempts to address these. This indicates the presence of an underlying competence in the ASD group.

However, the significant interaction shows that actual performance of the two groups clearly differed and between-participants t-tests in each condition separately showed that the extent of this audience design was significantly smaller among ASD than TD participants. The between-group difference in the number of complex referring terms used in the Knowledgeable Listener condition was not significant, $t(42) = .38$, $p = .70$, $d = 0.12$, $BF_{10} = 0.32$. However, TD children used significantly more complex referring terms than children with ASD in the Naïve condition, $t(42) = 2.36$, $p = .02$, $d = 0.71$, $BF_{10} = 5.15$. Thus, TD participants altered their usage of complex referring expressions according to listener needs to a significantly greater extent than did participants with ASD.

Figure 1. Proportion usage of complex referring term with knowledgeable and naïve listener



Discussion

The current study is the first to manipulate the role of social perspective-taking in the interpretation / production of verbal reference by children with ASD. This is important because a deficit in common ground understanding might not necessarily lead to impairments in audience design, if the speaker and listener's perspectives merely differ visually (Sanstieban et al., 2015; Moll & Kadipasaoglu, 2013). Therefore, we used collaborative tasks that manipulated the social common ground shared with an interlocutor. In Exp 1 (reference interpretation) we found that 5;0- to 7;11-year-olds with ASD were above chance in the use of interlocutor-specific common ground knowledge to accurately disambiguate referring terms and did not significantly differ in this regard from a matched TD control group. In Exp 2 (production), we also found that children with ASD showed evidence of taking social common ground into account; they used significantly more complex referring expressions (e.g. 'the big marble') in the Naïve condition (where complex referring terms were necessary to avoid ambiguity) than in the Knowledgeable condition. In this sense, their production behaviour ties in with their interpretation behaviour; they have the competence to take social common ground into account to drive verbal reference. However, the interaction effect found for production indicates that children with ASD were less able than TD peers to select a referring term based on whether a specific listener had previously shared the experience of constructing that particular toy.

Could the interpretation task have been resolved via a sub-mentalising heuristic?

In Exp 1 (reference interpretation), our control task ruled out the possibility that children with ASD might in the experimental task have simply blindly associated a particular experimenter with a particular activity. In this control task, the Requester had sat next to one of the two activities, but this association between Requester and activity was not sufficient to enable children in either group to interpret the ambiguous pronoun as referring to this activity. Moreover, it also cannot be the case that, for the experimental task, the children with ASD simply tracked the ambiguous pronoun back to the noun phrase (activity) which they had most recently heard (see Arnold et al., 2009). This is because for half the experimental trials per child, this would have led to false assumption that the target was the activity in which they had engaged with the non-requesting experimenter.

Exploring competence versus performance

Children with ASD thus can, on the one hand, demonstrate a competence for taking listener informational needs into account (i.e. significant difference between conditions for production task) but are nonetheless significantly less able to demonstrate this, in comparison to well-matched typical peers (as evidenced by the interaction effect). There are many reasons why the performance of children with ASD might be vulnerable, particularly if the task involves holding various elements in mind while planning a response, as was the case for our production task (e.g. Sikora, Roelofs, Hermans, & Knoors 2016).

Indeed, we might have found a between-groups difference if we had used a more complex interpretation task, such as one with several foils, or with several interlocutors, or a greater length of time between the shared experience and the test request. However, a between-groups difference in such a paradigm would not be due to a difference in the ability per se of the children with ASD to take in account the experience shared with a particular interlocutor; rather, it would be due to performance limitations, presumably relating to executive functioning or memory.

A good illustration of the difference between competence and performance in the interpretation of verbal reference can be seen in several studies of neurotypical adults (e.g. Cane, Ferguson & Apperly, 2017). These studies all manipulated level one visual perspective taking, for which no-one doubts neurotypical adult competence. Nonetheless, neurotypical adults make some errors in the privileged ground conditions of these ‘director task’ paradigms. Their ‘egocentric errors’ relate to inhibitory control (Brown-Schmidt, 2009) and cognitive flexibility (Lin, Eply & Keysar, 2010). Thus, while neurotypical adults have the competence to perform these reference interpretation tasks, they also have performance limitations. Future studies will need to explore why individuals with ASD seem on average to be more susceptible than the average neuro-typical individual to performance issues.

The manipulation of social common ground

The aspect of social common ground which we manipulated is relatively basic; TD 18-month-olds are capable of taking this into account to interpret pointing reference (Liebal et al., 2009). Nonetheless, our interpretation task (Exp 1) required some kind of implicit consideration of the knowledge to which a specific interlocutor had access and moreover, this knowledge cannot be based (as in previous ASD reference interpretation studies) on level one visual perspective-taking because when the Requester entered the room in the experimental trials, she could see neither the target nor the foil. Thus, we are the first to demonstrate that 5- to 7-year-olds with ASD can take interlocutor-specific knowledge into account in order to interpret reference. Indeed, the fact that the children with ASD showed a significant difference between the Knowledgeable and Naïve Listener conditions in Study 2 (Production) shows that they also demonstrated in production the competence to consider this when selecting a referring expression.

Liebal et al. (2009) interpreted the behaviour of the infants in their original study as indicating that they were taking ‘shared experience’ in account to interpret reference. If our group with ASD were doing so, this could be problematic for claims by Tomasello et al. (2005) that children with ASD do not demonstrate shared intentionality.

We exercise caution in this regard. It is possible that our ASD group would still have selected the target, if they had merely observed the Requester constructing the toy. If this were the case, then the skills needed by children with ASD to ‘pass’ the interpretation task would merely be intention-reading (see Carpenter, Pennington & Rogers, 2002), social coordination (Melis, Hare & Tomasello, 2006) and a willingness to help others (see Liebal, Colombi, Warneken & Tomasello, 2008, for autism).

Furthermore, there are many ways in which social common ground can be established and drawn upon when interpreting and producing verbal reference. In daily life, this often involves recalling shared experience over an extended period of time. It also often involves detecting not only what the interlocutor knows but also what he or she is likely to enjoy and / or find salient (e.g. Clark, Schreuder & Buttrick, 1983). This could be an area of difficulty in ASD since many individuals appear not to experience stimuli salience in a neuro-typical way (see e.g. O'Neill & Happé, 2000). It is certainly yet to be shown that individuals with ASD acknowledge that a joint commitment has been made towards a shared goal (see Tomasello & Hamann, 2012), which would be a stronger test of shared intentionality.

Summary

We have shown that children with ASD take interlocutor-specific prior experience into account in verbal reference interpretation and (to some extent) production. However, they lag behind well-matched typical peers in the degree to which they utilise information about prior shared experience in reference production. Future studies are needed to explore the precise components which lead to these disproportionate difficulties. This knowledge is essential for strategies to enable individuals with ASD to improve communication with family, peers and in the classroom.

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References

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

Arnold, J. E., Bennetto, L., & Diehl, J. J. (2009). Reference production in young speakers with and without ASD: Effects of discourse status and processing constraints. Cognition, 110(2), 131-146. doi:10.1016/j.cognition.2008.10.016

Banney, R. M., Harper-Hill, K., & Arnott, W. L. (2015). The ASD diagnostic observation schedule and narrative assessment: Evidence for specific narrative impairments in ASD spectrum disorders. International Journal of Speech-Language Pathology, 17(2), 159-171. doi:10.3109/17549507.2014.977348

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? Cognition, 21(1), 37-46. doi.10.1016/0010-0277(85)90022-8

Begeer, S., Malle, B. F., Nieuwland, M. S., & Keysar, B. (2010). Using theory of mind to represent and take part in social interactions: Comparing individuals with high-functioning ASD and typically developing controls. European Journal of Developmental Psychology, 7(1), 104-122. doi:10.1080/17405620903024263

Brown-Schmidt, S. (2009). The role of executive function in perspective taking during online language comprehension. Psychonomic Bulletin & Review, 16(5), 893-900. doi:10.3758/PBR.16.5.893

Carpenter, M., Pennington, B. F., & Rogers, S. J. (2002). Interrelations among social-cognitive skills in young children with autism. Journal of autism and developmental disorders, 32(2), 91-106. doi. 10.1023/A:1014836521114

Carpenter, M., Tomasello, M., & Striano, T. (2005). Role reversal imitation and language in typically developing infants and children with autism. Infancy, 8(3), 253-278. doi.10.1207/s15327078in0803_4

Charman, T., Jones, C. R., Pickles, A., Simonoff, E., Baird, G., & Happé, F. (2011). Defining the cognitive phenotype of autism. Brain research, 1380, 10-21. Doi. 10.1016/j.brainres.2010.10.075

Cane, J. E., Ferguson, H. J., & Apperly, I. A. (2017). Using perspective to resolve reference: The impact of cognitive load and motivation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 43(4), 591.doi:10.1037/xlm0000345.

Clark, H.H. (1996). Using language. Cambridge, England: Cambridge University Press.

Clark, H. H., & Marshall, C. R. (1981). Definite reference and mutual knowledge. In A. K. Joshi, B. L. Webher, & I. A. Sag (Eds.), Elements of discourse understanding. Cambridge: Cambridge Univ. Press.

Clark, H. H., Schreuder, R., & Buttrick, S. (1983). Common ground at the understanding of demonstrative reference. Journal of Verbal Learning and Verbal Behavior, 22(2), 245-258. doi. 10.1016/S0022-5371(83)90189-5

Colle, L., Baron-Cohen, S., Wheelwright, S., & van Der Lely, H.,K.J. (2008). Narrative discourse in adults with high-functioning ASD or asperger syndrome. Journal of ASD and Developmental Disorders, 38(1), 28. doi:10.1007/s10803-007-0357-5

Coull, G. J., Leekam, S. R., & Bennett, M. (2006). Simplifying Second-order Belief Attribution: What Facilitates Children's Performance on Measures of Conceptual Understanding? Social Development, 15(2), 260-275. doi: 10.1046/j.1467-9507.2006.00340.x

Constantino, J. N., & Gruber, C. P. (2007). Social responsiveness scale (SRS) Western Psychological Services Los Angeles, CA.

Dahlgren, S., & Dahlgren Sandberg, A. D. (2008). Referential communication in children with autism spectrum disorder. Autism: The International Journal of Research and Practice, 12(4), 335-348. doi:10.1177/1362361308091648 de Marchena, A., & Eigsti., I. (2016). The art of common ground: Emergence of a complex pragmatic language skill in adolescents with ASD spectrum disorders. Journal of Child Language. 43(1), 43-80. doi:10.1017/S0305000915000070

Fine, J., Bartolucci, G., Szatmari, P., & Ginsberg, G. (1994). Cohesive discourse in pervasive developmental disorders. Journal of ASD and Developmental Disorders, 24(3), 315-329. doi:10.1007/BF02172230

Frith, U., Morton, J., & Leslie, A. M. (1991). The cognitive basis of a biological disorder: Autism. Trends in Neuroscience, 14, 433-438. doi: 10.1016/0166-2236(91)90041-R

Fukumura, K. (2015). Development of audience design in children with and without ASD. Developmental Psychology, doi:10.1037/dev0000064

Gottmann, J., Gonso, J. & Rassmussen, B. (1975). Social interaction, social competence and friendship in children. Child Development, 46: 709-718. doi: 10.2307/1128569

Happé, F. G. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. Journal of autism and Developmental disorders, 24(2), 129-154. doi:10.1007/BF02172093

Jeffreys, H. (1961). Theory of probability (3rd ed.). Oxford: Oxford University Press, Clarendon Press.

Kern, A. & Moll, H. (2017). On the transformative character of collective intentionality and the uniqueness of the human. Philosophical Psychology, 30(3): 315-333. doi: 10.1080/09515089.2017.1295648.

Kuijper, S. J., Hartman, C. A., & Hendriks, P. (2015). Who is he? Children with ASD and ADHD take the listener into account in their production of ambiguous pronouns. PloS one, 10 (7). 10:e0132408. doi. 10.1371/journal.pone.0132408

Liebal, K., Behne, T., Carpenter, M., & Tomasello, M. (2009). Infants use shared experience to interpret pointing gestures. Developmental science, 12(2), 264-271. doi: 10.1111/j.1467-7687.2008.00758.x

Liebal, K., Colombi, C., Rogers, S. J., Warneken, F., & Tomasello, M. (2008). Helping and cooperation in children with autism. Journal of autism and developmental disorders, 38(2), 224-238. doi. 10.1007/s10803-007-0381

Lin, S., Keysar, B., & Epley, N. (2010). Reflexively mindblind: Using theory of mind to interpret behavior requires effortful attention. Journal of Experimental Social Psychology, 46(3), 551-556. doi. 10.1016/j.jesp.2009.12.019

Mäkinen, L., Loukusa, S., Leinonen, E., Moilanen, I., Ebeling, H., & Kunnari, S. (2014). Characteristics of narrative language in autism spectrum disorder: Evidence from the Finnish. Research in Autism Spectrum Disorders, 8(8), 987-996. doi. 10.1016/j.rasd.2014.05.001

Matthews, D., Lieven E & Tomasello, M. (2007). How toddlers and preschoolers learn to uniquely identify referents for others: A training study. Child Development. 78(6), 1744-1759. doi: 10.1111/j.1467-8624.2007.01098.x

Melis, A. P., Hare, B., & Tomasello, M. (2006). Engineering cooperation in chimpanzees: tolerance constraints on cooperation. Animal Behaviour, 72(2), 275-286. doi. 10.1016/j.anbehav.2005.09.018

Moll, H., & Kadipasaoglu, D. (2013). The primacy of social over visual perspective-taking. Frontiers in Human Neuroscience, 7, 558. doi:10.3389/fnhum.2013.00558

Nadig, A., Seth, S., & Sasson, M. (2015). Global similarities and multifaceted differences in the production of partner-specific referential pacts by adults with autism spectrum disorders. Frontiers in Psychology, 6. doi:10.3389/fpsyg.2015.01888

Nadig, A., Vivanti, G., & Ozonoff, S. (2009). Adaptation of object descriptions to a partner under increasing communicative demands: A comparison of children with and without

ASD. ASD Research, (2), 334-347. doi:10.1002/aur.102

Norbury, C. F., & Bishop, D. V. M. (2003). Narrative skills of children with communication impairments. International Journal of Language & Communication Disorders, 2003, , 38(3), 287-313.doi:10.1080/136820310000108133

O’Neill, D. K. (2005). Talking about “new” information: The given/new distinction in children’s developing theory of mind. In J. W. Astington & J. A. Baird (Eds.), Why language matters for theory of mind (pp. 84–105). Oxford, United Kingdom: Oxford University Press

O’Neill, D.K. & Happé, F. G. (2000). Noticing and commenting on what's new: differences and similarities among 22-month-old typically developing children, children with Down syndrome and children with autism. Developmental Science, 3(4), 457-478. doi:10.1111/1467-7687.00139

Perner, J., Leekam, S. R., & Wimmer, H. (1987). Three-year-olds’ difficulty with false belief. British Journal of Developmental Psychology, 5, 125 – 137. 10.1111/j.2044-835X.1987.tb01048.x

Rakoczy, H. (2017). The development of collective intentionality. In K. Ludwig & M. Jankovic (Eds.), The Routledge Handbook of Collective Intentionality. London: Routledge.

Rubin, K. H. (1972). Relationship between egocentric communication and popularity among peers. Developmental Psychology, 7(3), 364. doi. 10.1037/h0033348

Santiesteban, I., Shah, P., White, S., Bird, G., & Heyes, C. (2015). Mentalizing or submentalizing in a communication task? Evidence from ASD and a camera control. Psychonomic Bulletin & Review, 22(3), 844-849. doi:10.3758/s13423-014-0716-0

Schmerse, D., Lieven, E., & Tomasello, M. (2015). Young children use shared experience to interpret definite reference. Journal of Child Language. 42(5): 1146-1157.

Schuh, J. M., Eigsti, I. M., & Mirman, D. (2016). Discourse comprehension in autism spectrum disorder: Effects of working memory load and common ground. Autism Research, 9(12), 1340-1352. doi. 10.1002/aur.1632

Sikora, K., Roelofs, A., Hermans, D., & Knoors, H. (2016). Executive control in spoken noun-phrase production: Contributions of updating, inhibiting, and shifting. The Quarterly Journal of Experimental Psychology, 69(9), 1719-1740. doi: 10.1080/17470218.2015.1093007

Suh, J., Eigsti, I., Naigles, L., Barton, M., Kelley, E., & Fein, D. (2014). Narrative performance of optimal outcome children and adolescents with a history of an ASD spectrum disorder (ASD). Journal of ASD and Developmental Disorders, 44(7), 1681-1694. doi:10.1007/s10803-014-2042-9

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: the origins of cultural cognition. Behavioral and Brain Sciences, 28: 675-735. doi: 10.1017/S0140525X05440121

Tomasello, M., & Hamann, K. (2012). The 37th Sir Frederick Bartlett Lecture: Collaboration in young children. Quarterly Journal of Experimental Psychology, 65(1), 1-12. doi. 10.1080/17470218.2011.608853

Volden, J. (2002). Features leading to judgements of inappropriacy in the language of speakers with ASD: a preliminary study. Journal of Speech-Language Pathology and Audiology, 26(3): 138-146.

Volden, J., Mulcahy, R. F., & Holdgrafer, G. (1997). Pragmatic language disorder and perspective taking in autistic speakers. Applied Psycholinguistics, 18(2), 181-98. doi:10.1017/S0142716400009966.

Wellman, H. & Liu, D. (2004). Scaling of theory-of-mind tasks. Child Development, 75(2), 523-541. 10.1111/j.1467-8624.2004.00691

White, S., Hill, E., Happé, F., & Frith, U. (2009). Revisiting the Strange Stories: Revealing Mentalizing Impairments in Autism. Child Development, 80(4), 1097-1117. doi:10.1111/j.1467-8624.2009.01319.x

Table Legends

Table 1. Means (SD in brackets) for participant characteristics

Table 2. Construction activity pairs and common missing items (comprehension measure)

Table 3. List of referents and their competitors (production measure)