Social Understanding in Autism:  
Eye Gaze as a Measure of Core Insights

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Twenty-eight children with autism and 33 MLD children were given two tasks tapping social understanding and a control task tapping probability understanding. For each task there was a measure of eye gaze (where children looked when anticipating the return of a story character or an object) and a verbal measure (a direct question). We found that eye gaze was better than verbal performance at differentiating children with autism from children with MLD. Children with autism did not look to the correct location in anticipation of the story character’s return in the social tasks, but they did look to the correct location in the nonsocial probability task. We also found that within the autistic group, children who looked least to the correct location were rated as having the most severe autistic characteristics. Further, we found that whereas verbal performance correlated with general language ability in the autistic group, eye gaze did not. We argue that: (a) eye gaze probably taps unconscious but core insights into social behavior and as such is better than verbal measures at differentiating children with autism from mentally handicapped controls, (b) eye gaze taps either spontaneous processes of simulation or rudimentary pattern recognition, both of which are less based in language, and (c) the social understanding of children with autism is probably based mostly on verbally mediated theories whereas control children also possess more spontaneous insights indexed by eye gaze.

Keywords: Autistic disorder, eye gaze, explicit, implicit, language, theory of mind.

Abbreviations: MLD: moderate learning difficulty.

A long line of research on children with autism indicates that they have a marked deficit in their theory of mind (see Happé, 1995, for a summary). For instance, they fail false belief tasks (e.g., Baron-Cohen, Leslie, & Frith, 1985; Eisenmajer & Prior, 1991; Leslie & Frith, 1988; Perner, Frith, Leslie, & Leekam, 1989; Ziatas, Durkin, & Pratt, 1998) that normal children typically pass by 4 years of age and other children with low IQ often pass. To varying degrees they also have difficulty on many other theory of mind tasks (Baron-Cohen, 1991). For instance, they have difficulty recognizing what emotions are conveyed in point light displays (Moore, Hobson, & Lee, 1997). There have, however, been a number of studies in which performance by control children on tasks of social understanding has been as impaired as that of children with autism. For instance, Yirmiya and Shulman (1996) found no difference in theory of mind ability between a group of children with autism and a group of low IQ children once general verbal ability had been controlled for. Tager-Flusberg and Sullivan (1994) found that children with autism were impaired at explaining behavior in terms of false belief, but that there were no differences between control children and children with autism on a standard false belief task. Bowler (1997) found no differences between the reasoning of high-functioning autistic and Asperger’s adults on second-order false belief tasks relative to nonautistic adults. Prior, Dahlstrom, and Squires (1990) found that, relative to control children, children with autism were not impaired on an emotion recognition task and on some false belief tasks they were given. Muris, Steerneman, and Merckelbach (1998) found that socially immature children were as bad on a false belief task as were atypical children with autism. Charman and Lynggaard (1998) found no autism-specific deficit in false belief understanding relative to low-IQ control children.

Despite the conflicting results between the two sets of studies discussed above, they have one thing in common. They have involved giving children verbal theory of mind tasks, typically based on those given to normal children. Children were told a story or shown some stimuli such as a picture, and were asked what a protagonist would think, feel or do. In contrast, another line of research has used behavioral indices and has focused more on general social understanding than on theory of mind (i.e., understanding of mental states) per se. There are a number of studies which indicate that the social understanding of children with autism is impaired. Children with autism tend not to look to others’ faces to share attention or engage in gaze following or protodeclarative pointing (Cox et al., 1999; Curcio, 1978; Leekam, Hunnissett, & Moore, 1998; Loveland & Landry, 1986; Mundy, Sigman, Ungerer, & Sherman, 1986; Wetherby & Prutting, 1984). Younger children with autism have

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also been shown to look less to persons who display facial expressions of distress or fear (Sigman, Kasari, Kwon, & Yirmiya, 1992). Further, whereas mentally retarded children seem to find a distressed experimenter aversive, such that they lean back from the experimenter, children with autism do not lean back (Corona, Dissanyake, Arbelle, Wellington, & Sigman, 1998). In addition, children with autism have been shown to examine objects differently from control children. Swettenham et al. (1998) examined attention shifting between two people, two objects, or an object and a person. They found that 20-month-old infants with autism tended to look less and for shorter durations at people, and for longer durations at objects, and to shift gaze less between objects and people than did a control group of developmentally delayed infants or normally developing infants. The latter difference in gaze shifting may indicate a lack of social referencing in the children with autism. Likewise, a recent study by Griffith, Pennington, Wehner, and Rogers (1999) found that, relative to a group of age- and IQ-matched developmentally delayed children, 4-year-old children with autism showed impairments in joint attention (sharing attention with another person regarding an object) and social interaction (e.g., turn-taking and the extent to which they interacted with another person).

In studies of normally developing children, Clements and Perner (1994) were among the first to show a marked dissociation between behavioral and explicit verbal measures. They used both a verbal question and eye gaze as a measure of false belief understanding. The story character hid the object in a left-hand location, went away, and a second character moved it to a right-hand location. Clements and Perner videotaped children's eye movements as they watched the story. Just before the story character returned, the child heard a prompt. The narrator of the story announced that the story character was about to return and then wondered aloud, "I wonder where (Sam) will look?" This was not a direct question to the child regarding where the character would look (i.e., children did not answer verbally), but rather, a means of determining whether the child anticipated Sam returning to the left-hand location where he had placed the object or to the right-hand location where the object had been moved to. Clements and Perner's finding was that children's eye gaze while watching the story revealed an earlier sensitivity to belief than did their explicit response. Children from about 2 years and 11 months looked correctly to the left-hand location when anticipating Sam's return even when they indicated he would go to the incorrect (right-hand) location when asked directly.

Clements and Perner (1994) suggested that children's eye gaze may reflect implicit knowledge of false belief. Ruffman, Garnham, Import, and Connolly (in press) supported this claim in a recent study (also see Ruffman, 2000). They examined whether eye gaze in a false belief task might index explicit (conscious) knowledge that children do not hold with much confidence and hence revert to a different answer when asked explicitly. Children bet counters in a false belief task according to where they thought the story character would return. Younger children who looked correctly to the left-hand location when anticipating Sam's return, but all their counters on the right-hand location where they said Sam would go. Thus, children bet on the location consistent with their verbal answer rather than their eye gaze. Importantly, a control condition showed that betting was sensitive to small variations in certainty. For instance, children bet on whether they thought an object drawn randomly from a bag would be red or green. Children bet with significantly less certainty when there were 9 red objects and 1 green object in comparison to when there were 10 red and 0 green. These results are consistent with the idea that in the false belief task children were genuinely unaware that the character would go to the left-hand location (where they looked) because they were fully confident in their verbal answer.

In addition, Garnham and Ruffman (2001) showed that eye gaze genuinely tapped false belief understanding. They used three locations in their task. With two locations it is conceivable that eye gaze is based on a rudimentary understanding of seeing and knowing, potentially tapped in other tasks that utilize behavioral measures (O'Neill, 1996). Thus, one might go to the wrong location not because one thinks the object is there, but because one didn't see the transfer and children believe not seeing leads to doing the wrong thing (Ruffman, 1996). With two locations the wrong location happens to coincide with the correct "believed" location. With three locations there are two wrong locations but only one "believed" location (where the character put the object initially). Hence, a strategy based on "doing the wrong thing" would result in random looking at either of the two empty locations, whereas a strategy based on belief would result in looking only at the initial location. Consistent with the idea that eye gaze reflects genuine insight into false belief, Garnham and Ruffman found looking only at the initial location. Together, the results of Ruffman et al. (in press) and Garnham and Ruffman indicate that anticipatory eye gaze in tasks of this nature typically taps the same basic concept as verbal answers (e.g., false belief), but does so by tapping into unconscious knowledge (children don't know that they know) rather than verbally based conscious knowledge.

In the present study we examine whether the behavioral measure of eye gaze is better at differentiating children with autism from a group of children with moderate learning difficulty (MLD), and whether the understanding of children with autism is primarily verbally mediated. We argue that in normally developing children, their initial understanding of the social world is probably implicit and manifest in behavioral measures such as eye gaze. This understanding might be either innate, or could simply evolve from infants' interest in the human face (which allows a window into the mind), or their observations of the social world which allow them to pattern match (i.e., connect various social outcomes with certain preconditions). Over time, and as their language develops, such children develop a consciously mediated and verbally based theory on the basis of these implicit intuitions. Language gives children the tools for reflecting on and refining their implicit insights to make them explicit.

In contrast, children with autism may come to understand the social world in a different way. They might lack the initial implicit understanding and, as a result, the social understanding that the gifted group of autistic children eventually develop might be based on processes of focused induction or teaching rather than reflecting on implicit intuitions to make them explicit theories. In other words, both high-functioning children with autism and children without autism might develop an explicit, theoretical understanding of the social world. However, children with autism might not base their theory on a rich set of intuitions, as do children without autism. Instead,
they must learn by diligently and consciously working out insights for themselves, or rely on teachers or parents for teaching. In an important sense, then, we see the implicit, intuitive insights as reflecting the core social understanding.

Previous research is consistent with this analysis. There is growing evidence that low-IQ control children are often as impaired as children with autism on tasks of verbal social understanding (perhaps due to an increasing emphasis on teaching social skills to children with autism). At the same time, it is arguably the case that children with autism show a more uniform deficit on behavioral measures. In our view this makes perfect sense if behavioral measures often tap insights that are more central to real world social ability than explicit verbal measures. This is probably true for at least two reasons (Ruffman, 2000). First, in real life social interactions one need only have some inkling of how another person will act. There is often no need to verbalize insights, so any understanding will be manifest in behavior and may even be unconscious. Second, young children are relative novices with regard to their social understanding. Much of their social knowledge will undergo extensive change and cognitive development may be characterized by a pattern of implicit knowledge before explicit knowledge (Kamiloff-Smith, 1992).

This implicit knowledge may serve an important function in the world in that it enables meaningful communication even when the child cannot verbalize or think explicitly about the insights. As an example, consider the 12-month-old infant who, when on a visual cliff and uncertain of whether to proceed, looks to its mother. If the mother looks fearful the infant stops, and if she looks happy the infant proceeds (Sorce, Emde, Campos, & Klinnert, 1985). This shows that 12-month-olds can successfully interpret (i.e., react appropriately to) the significance of their mother’s emotional expression of fear or happiness. Perner (1991) pointed out that infants need not understand the mental states that underlie the mother’s emotional expression. They need only react appropriately to her behavioral expression of emotion. It is equally clear that infants cannot verbalize their understanding (i.e., label their mother’s emotion or the situation as dangerous), and it is at least an open question whether they are conscious of how their mother feels. Nevertheless, the understanding that is needed for successful performance on the visual cliff, and is manifest in a behavioral measure, is absolutely essential to the infant’s very survival and in this respect there could not be a better measure of social understanding.

In sum, we think that implicit behavioral measures of understanding may tap core social insights. This is not to say that conscious verbal understanding is unimportant. It seems clear that conscious understanding enables a certain degree of flexibility in utilizing knowledge. It also seems clear that later developing explicit knowledge is in some ways more sophisticated than early implicit knowledge so that one could imagine it being important to social abilities. It is just that implicit behavioral measures may be more important for many social interactions.

We tested these ideas with tasks that were based on the method used by Clements and Perner (1994). We chose not to use false belief tasks because teachers at the special schools we visited informed us that children with autism had received extensive instruction about false belief using standard false belief tasks. This is not surprising given that false belief deficits are one of the most well-established social features of autism. To this end we used two novel tests of social understanding. In the Desire-Behavior task the child was required to understand that a person would search for a desired object rather than a nondesired object. In the Statement-Behavior task the child was required to understand that a person would search in a room that he had been told is safe rather than in an unsafe room. Children were also given a control task that required them to reason about probabilities rather than social events. Our expectation was that children with autism would look to the correct location in the control task but not the social tasks, because their cognitive deficit is restricted to social knowledge.

We chose the two social tasks so as to be different to the tasks used in previous research with children with autism and hence extend those findings. Both tasks were also nonmetarepresentational in that they did not require children to reflect on another person’s mental states as representations. In the Desire-Behavior task children needed to understand the link between desires and behavior, but such an insight is not typically construed as metarepresentational (Perner, 1991). In the Statement-Behavior task children needed only to connect one person’s utterance to another person’s behavior without having to understand an intervening representational state. Nevertheless, the research reviewed above shows that behavioral measures that tap nonmetarepresentational social insights are good at differentiating children with autism from control children.

In addition, teachers were given a questionnaire based on the diagnostic criteria of the American Psychiatric Association for autism. Our aim was to use teachers’ responses to categorize the severity of autistic symptoms individual children possessed, and to examine whether ratings related to eye gaze and verbal responses. If our hypotheses are correct, then there should be a significant correlation between eye gaze and teachers’ ratings of autistic severity within the autistic group such that children who have more severe autistic symptoms also look least to the correct location. In contrast, we would expect lower correlations between verbal responses and autism ratings. We also expect no real correlation between autism ratings and eye gaze or verbal responses in the control group. Because these children are not autistic, ratings regarding autistic tendencies are not relevant to their real world social abilities so that correlations with social understanding should be low.

Another issue that we address is how general language ability relates to eye gaze. A wealth of research indicates that there is a correlation between autistic children’s performance on standardized language tests and verbal performance on theory of mind tasks (e.g., Charman & Lynggaard, 1998; Eisenmajer & Prior, 1991; Happé, 1995; Kazak, Collis, & Lewis, 1997; Prior et al., 1990; Tager-Flusberg & Sullivan, 1994). Yet, it is unknown whether language ability is related to performance on behavioral measures. Further, we are interested in whether there would be a different pattern of correlations between language, verbal performance, and eye gaze in children with autism relative to control children. If language correlated with verbal performance but not eye gaze in children with autism, but some other pattern was obtained in control children, this might be evidence for the idea that the social understanding of children with autism was verbally mediated and distinctly different to that of control children.
Table 1
Language and IQ Scores

<table>
<thead>
<tr>
<th></th>
<th>Chronological age</th>
<th>BPVS Verbal Mental Agea</th>
<th>BPVSB</th>
<th>CELF: Sentence Structureb</th>
<th>CELF: Linguistic Conceptsb</th>
<th>WPPSI: Informationb</th>
<th>Total languageb</th>
<th>WPPSI: Picture Completionb (Spatial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children with autism (N = 28)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.33</td>
<td>1.84</td>
<td>4.1</td>
<td>3.4</td>
<td>4.8</td>
<td>4.4</td>
<td>13.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Mean</td>
<td>9.35</td>
<td>5.27</td>
<td>11.7</td>
<td>16.6</td>
<td>12.3</td>
<td>18.4</td>
<td>59.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Children with MLD (N = 33)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.18</td>
<td>1.51</td>
<td>3.3</td>
<td>2.7</td>
<td>3.0</td>
<td>4.0</td>
<td>10.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Mean</td>
<td>8.54</td>
<td>5.15</td>
<td>11.5</td>
<td>16.9</td>
<td>13.7</td>
<td>19.5</td>
<td>61.8</td>
<td>18.1</td>
</tr>
</tbody>
</table>

BPVS: British Picture Vocabulary Scale; CELF: Clinical Evaluation of Language Fundamentals; WPPSI: Wechsler Primary and Preschool Scale of Intelligence.

*Standard score.

Raw score.

Method

Participants

There were 28 children with autism and 33 children with MLD. The children with autism had all received a formal diagnosis of autism by experienced clinicians using American Psychiatric Association diagnostic criteria. The MLD children were similarly diagnosed as having MLD with unknown etiology. The children were matched on standardized tests of language, including two subtests of the Clinical Evaluation of Language Fundamentals (CELF)-preschool test (Sentence Structure and Linguistic Concepts), the British Picture Vocabulary Scale (BPVS), and two subtests of the Weschler Primary and Preschool Scale of Intelligence (WPPSI: Information as a measure of verbal ability, and Picture Completion as a measure of performance or spatial ability). All children were from special schools in or around London, U.K. Table 1 shows the mean scores on each of the verbal and spatial ability tests. T-tests revealed that the two groups were not significantly different in terms of their overall scores on the language composite, or on the Picture Completion task.

Materials

Figure 1 provides an illustration of the apparatus used in the Desire-Behavior and control tasks. These tasks employed a box containing two slides. The slide openings at the rear of the box were adjacent and the distance between the slide openings at the front of the box was 40 cm. The openings of the slides were different colors (red and green) and the openings of the slides were adjacent to similarly colored boxes. Small plastic characters were used in the Desire-Behavior task that could slide down the slides and look in the boxes. In the control task red cubes and green balls were used to slide down the slides. In one condition of the Desire-Behavior task the story character was said to like an apple but not like an orange. In the other condition he was said to like a car but not a ball. The Statement-Behavior tasks employed three different cardboard houses, each with two windows and a door leading to a hallway in between (see Figure 2). The door to the hall could be opened to reveal two more doors on either side, each leading to a room (and a window). Rooms were visible through the open windows on the front of the house and were different colors or designs. The windows were 40 cm apart. The father was 35 cm tall, made of cardboard, and sat on top of the house. A video camera was placed above the house and beside the father so that the child’s eye movements could be recorded when viewing the story. All stories were narrated on audiotape and the tape was paused at different points so the experimenter could ask questions.

Teachers of the children were also given a 26-item questionnaire based on the diagnostic criteria for autism (see Appendix A).
Procedure

A verbatim transcript of the stories is included in Appendix B. In the Desire-Behavior task the child listened to an audiotaped narrative in which a character expressed a desire for one object but not another. He put the desired object in one box (counterbalanced as to left or right) and the other object in the other box and went away. Later, the narrator told the child that the character was about to return to get something to eat (or play with), and then wandered out loud where he would go. Children were videotaped as they listened to the story and their anticipatory eye gaze was measured for 4 seconds when the narrator announced the character would return, and then again for 4 seconds when he wondered out loud where the character would go. The child was then asked directly where the story character would go. We will refer to this direct question as the verbal measure. There were two Desire-Behavior conditions. In the second condition two new objects, a different location for the desired object, and a different story character were used.

There was a training phase in the Statement-Behavior task used to teach children that when a character goes into a room he subsequently appears in the room’s window. For this reason the training phase was somewhat lengthy, but it was clearly successful in that children’s performance on the verbal question of the experimental phase (Which window will Sam go to?) showed our aim was achieved (see below). There were two conditions in the experimental phase. In each condition a boy asked his father whether he could go into a house. The father said that only one room was safe. The boy then asked if a particular room (e.g., the red room) was safe. The father said “Yes” in one condition and “No” in the other. Thus, the boy should have gone into opposite rooms in the two conditions. Next, the narrator announced that the boy would go into one of the rooms, and wondered aloud which room he would go into. Again, anticipatory eye gaze was measured for a total of 8 seconds, 4 seconds when the narrator announced that the boy would go into a room, and 4 seconds when he wondered out loud which room the boy would go to. The child was then asked directly which room the boy would go into (the verbal measure).

The control task tapped eye gaze and reasoning in a nonsocial task. Children were shown that red cubes could only come down the red slide and that green balls could only come down the green slide. In one condition children were then shown a bag with 10 red cubes (and no green balls) inside. The narrator announced that the experiment was about to put an object down a slide, and wondered aloud which slide the object would come down. Anticipatory eye gaze was again measured for a total of 8 seconds: 4 seconds when the narrator announced that an object would be launched down a slide, and 4 seconds when he wondered out loud which slide the object would come down. The child was then asked directly which slide the object would come down (the verbal measure). The second control condition was identical except that a bag with 10 green balls and no red cubes was used. Tasks were given in a counterbalanced order with the control task preceding the social tasks half the time and following the social tasks half the time.

Scoring. Videotapes of the child’s eye gaze were viewed in slow motion and looking time was analyzed frame-by-frame. The videotapes were coded with a button box connected to the video recorder and a computer loaded with appropriate software to measure looking time at the left- and right-hand locations, and looking away. Thus looking time was accurate to 0.04 seconds. Children were counted as passing the verbal measure if they correctly indicated where the story character would go when asked directly. For some analyses, eye movements were counted as correct if, over the two 4-second time windows (8 seconds in total) of a single condition, children looked more to the correct location (e.g., looked to the right when the desired object was in the right-hand container). Scores for each task ranged from 0 to 2. No children were excluded from the analyses for having failed memory questions. Note that the method of scoring eye gaze, where correct performance comprises looking more to the correct location, is analogous to that for the verbal measure. With the verbal measure children are compelled to choose one room even if they feel that the character is nearly as likely to go to the other. One rater rated all children’s eye gaze and a second rater rated 23% of videotapes for both children with autism and children with MLD. For each participant group, raters agreed 86% of the time as to whether the child was looking more to the correct location. In cases of disagreement the primary rater’s coding was used.

Results

If children were disengaged in our tasks at the eye gaze prompts then we would expect them to look away (perhaps particularly in the social tasks for the children with autism). However, there was no difference in the extent to which children in the two groups looked at the two locations (correct location plus incorrect location) in each task. For these purposes, time spent looking away was not included in the calculations. We calculated the mean time spent looking at the two locations over the social tasks (Desire-Behavior and Statement-Behavior). That is, because there was only one control condition and two social conditions, we took the total time in the social conditions and divided this by two. Children with autism looked for an average of 5.91 out of 8.00 seconds on the social tasks and children with MLD looked for 5.76 seconds, t(59) = 0.33, n.s. On the control tasks children with autism looked for an average of 5.13 seconds and children with MLD looked for 5.26 seconds, t(59) = 0.15, n.s. Thus, the trend was actually in the opposite direction, with children in both groups looking more in the social tasks than in the control task.

Table 2 lists the amount of time children in the two groups spent looking at the correct and incorrect locations in each task and on the two social tasks combined. We examined this data with two repeated measures analyses of variance. First, we used a 2 (group: autism versus MLD) × 2 (location: correct versus incorrect) analysis of variance, with looking time in the social tasks as the dependent variable. The main effect for location was significant, F(1,59) = 49.20, p < .001, indicating that children tended to look at the correct location more than the incorrect location. In addition, the interaction was significant, F(1,59) = 4.17, p < .05, indicating that children with MLD tended to show the correct pattern of looking at a greater rate than children with autism. There was no effect for group. We then conducted an identical analysis with looking time in the control task as the dependent variable. Only the main effect for location was significant, F(1,59) = 56.36, p < .001. The main effect for group did not approach significance, nor did the interaction, F(1,59) = 0.21, n.s. Thus, the advantage shown by children with MLD on the social tasks was not shown on the control task.

To compare the verbal measure to eye gaze, children’s eye gaze was then coded as a dichotomous measure as either: (a) child looked more at the correct location, or (b)
Table 2
Looking Times (SDs) at the Correct and Incorrect Locations in the Different Tasks (in Seconds)

<table>
<thead>
<tr>
<th></th>
<th>Children with autism</th>
<th>Children with MLD</th>
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<tbody>
<tr>
<td></td>
<td>Looking at</td>
<td>Looking at</td>
</tr>
<tr>
<td></td>
<td>correct location</td>
<td>incorrect location</td>
</tr>
<tr>
<td>Desire-Behavior</td>
<td>2.66 (1.64)</td>
<td>2.15 (1.69)</td>
</tr>
<tr>
<td>Statement-Behavior</td>
<td>4.63 (2.78)</td>
<td>2.38 (2.00)</td>
</tr>
<tr>
<td>Social composite</td>
<td>3.65 (1.67)</td>
<td>2.27 (1.37)</td>
</tr>
<tr>
<td>Control</td>
<td>4.20 (3.51)</td>
<td>0.93 (1.07)</td>
</tr>
<tr>
<td></td>
<td>2.82 (1.86)</td>
<td>1.40 (1.51)</td>
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<tr>
<td></td>
<td>5.44 (2.99)</td>
<td>1.85 (1.42)</td>
</tr>
<tr>
<td></td>
<td>4.13 (1.61)</td>
<td>1.62 (0.98)</td>
</tr>
<tr>
<td></td>
<td>4.08 (2.34)</td>
<td>1.18 (1.58)</td>
</tr>
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Table 3
Number (and Percentage) of Children Looking More at the Correct Location on the Social and Control Tasks

<table>
<thead>
<tr>
<th>No. of tasks looking more at correct location</th>
<th>Verbal question</th>
<th>Eye gaze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desire-Behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2 (7)</td>
<td>6 (21)</td>
</tr>
<tr>
<td>1</td>
<td>10 (36)</td>
<td>19 (68)</td>
</tr>
<tr>
<td>2</td>
<td>16 (57)</td>
<td>3 (11)</td>
</tr>
<tr>
<td>Mean</td>
<td>1.50 (75)</td>
<td>0.89 (45)</td>
</tr>
<tr>
<td>SD</td>
<td>0.64</td>
<td>0.57</td>
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<tr>
<td>Statement-Behavior</td>
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<tr>
<td>0</td>
<td>3 (11)</td>
<td>5 (18)</td>
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<tr>
<td>1</td>
<td>8 (29)</td>
<td>11 (39)</td>
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<tr>
<td>2</td>
<td>17 (61)</td>
<td>12 (43)</td>
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<tr>
<td>Mean</td>
<td>1.50 (75)</td>
<td>1.25 (63)</td>
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<tr>
<td>SD</td>
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<td>0.75</td>
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<td>Social composite</td>
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<td>1 (4)</td>
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<td>4</td>
<td>9 (32)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Mean</td>
<td>3.00 (75)</td>
<td>2.14 (54)</td>
</tr>
<tr>
<td>SD</td>
<td>0.98</td>
<td>0.93</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0 (0)</td>
<td>4 (14)</td>
</tr>
<tr>
<td>1</td>
<td>0 (0)</td>
<td>8 (29)</td>
</tr>
<tr>
<td>2</td>
<td>28 (100)</td>
<td>16 (57)</td>
</tr>
<tr>
<td>Mean</td>
<td>2.00 (100)</td>
<td>1.43 (72)</td>
</tr>
<tr>
<td>SD</td>
<td>0</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Percentages are in brackets. Maximum total score for all tasks was 2, except for the social composite where the maximum was 4.

child looked more at the incorrect location or there was no difference. This data is included in Table 3. Performance on the verbal measures was approximately equal across all tasks in the two groups. Indeed, the children with autism had a slight advantage on the social tasks. On the social tasks the eye gaze of the MLD children was at about the same level of success as their verbal performance. Further, the MLD children were more likely to look to the correct location in the social tasks than were children with autism. In contrast, on the control task both groups were equally likely to look at the correct location.

Eye gaze in the two groups was compared using Mann-Whitney U tests. Children with MLD were more likely to look at the correct location than children with autism in the Desire-Behavior task, \( U = 344.50, p = .05 \), the Statement-Behavior task, \( U = 340.50, p < .05 \), and over the two social tasks together, \( U = 277.00, p < .005 \). However, there was no difference in the control task, \( U = 462.00, p = 1.00 \). In contrast, there was no difference in verbal performance between the two groups in the Desire-Behavior task, \( U = 447.00, p = .81 \), the Statement-Behavior task, \( U = 445.00, p = .78 \), the two social tasks together, \( U = 432.50, p = .65 \), or in the control task, \( U = 462.00, p = 1.00 \). Thus, eye gaze was better than verbal performance at differentiating the two groups.

In the next set of analyses we used Wilcoxon Sign tests to check whether eye gaze was significantly different from verbal performance within each group for each task. The children with autism were less likely to look at the correct location than they were to give correct verbal answers only in the control task, \( z = 3.06, p < .005 \). The MLD children were significantly less likely to look at the correct location than they were to give correct verbal answers only in the control task, \( z = 3.52, p < .001 \). We interpret the results for the control task in the Discussion section.
One could argue against comparisons with the control task because children did better on the verbal question of the control task than they did on the verbal questions of the social tasks. For this reason we compared social and control eye gaze only in the children who passed all four verbal questions of the social tasks (and who also passed the verbal questions of the control tasks). There were 10 children with MLD and 9 children with autism who did this. The children with autism scored 2.44 out of 4 on social eye gaze, whereas the children with MLD scored 3.30. A Mann-Whitney U test showed that there was a significant difference between the eye gaze scores in the two groups, $U = 22.50, p = .05$. In contrast, there was no difference in eye gaze on the control task. The children with autism scored 1.33 out of 2, whereas the children with MLD scored 1.40, $U = 44.00, p = .93$. Thus, differences in social eye gaze but not control eye gaze were obtained in both the whole sample, and in the group for whom there was no difference in verbal performance on the control and social tasks.

The means examined above do not shed light on how many individual children showed some understanding on our tasks. We deemed a child to have passed the verbal measure of the Desire-Behavior task if they scored 2 out of 2. This would occur by chance one time out of four. A score of 0 or 1 was deemed a failure. Similar pass/fail measures were used for the eye gaze measure and for the Statement-Behavior task. Table 4 lists children’s performance on the two measures. Children with autism were more likely to give a correct verbal answer in the Desire-Behavior task than to look more to the correct location, McNemar’s $\chi^2(1, N = 15) = 11.27, p < .01$. The same pattern was present on the Statement-Behavior task, McNemar’s $\chi^2(1, N = 11) = 4.45, p < .05$. In contrast, there was no difference in verbal performance and eye gaze for children with MLD on either the Desire-Behavior task, McNemar’s $\chi^2(1, N = 11) = 2.27$, n.s., or the Statement-Behavior task, McNemar’s $\chi^2(1, N = 14) = 0.00$, n.s.

The above analyses establish that children with autism were less likely than children with MLD to look at the correct location. Another question is whether, within the autistic group, children who have more severe autistic symptoms were also the least likely to look at the correct location. To examine this issue we used teachers’ ratings of each participant’s autistic characteristics (see Appendix A). For all items except item 18 and items 23 to 26, a high score meant a lack of autistic tendencies and a low score meant the presence of autistic tendencies. The scores on items 18 and 23 to 26 were reversed for this reason to give an average score between 0 and 10 for each child. Recall that low ratings indicated more severe autistic symptoms. Teachers gave children with autism an average rating of 3.77 ($SD = 1.82$), whereas they gave children with MLD a rating of 4.59 ($SD = 1.60$). Children with autism were rated as having significantly more severe autistic symptoms than children with MLD, $t(59) = 3.45, p < .001$. This result simply helps to establish the ratings as a valid means of assessing autistic severity.

The correlation over all children between language ability as measured by the language composite and autism ratings was $r = .59, p < .001$. This correlation is consistent with findings that linguistic ability is a correlate of social skills ratings in normally developing children (Watson, Nixon, Wilson, & Capage, 1999). It is possible that teachers base their ratings partially on who they think is an intelligent child (with language the best indicator of intelligence), and what behaviors they think an intelligent child would engage in. To ensure that autism ratings were not confounded with language ability, we partialled out language ability before examining other correlations with autism ratings. Correlations between teacher ratings and social eye gaze, social verbal performance, and control eye gaze (with language partialled out) are shown in Table 5. Verbal performance on the control task is not considered because there was no variance to explain on this task. In the group of children with autism, there was a high partial correlation between autism ratings and social eye gaze such that children who had less severe autistic characteristics had better eye gaze. In contrast, the partial correlation between autism ratings and social verbal performance was not significant. No correlations were significant in the group of children with MLD. This result was expected. Ratings of autistic characteristics will be irrelevant to these children and uninformative regarding their social ability because they are not autistic.

The final analyses examined the ways in which the language and IQ tests correlated with verbal performance
and eye gaze in the two groups. Table 6 shows how the different tasks correlated with one another in the two groups of children. For the children with autism, the correlation between verbal performance on the social tasks and the language composite was positive and significant. In contrast, the correlation between verbal performance on the social tasks and the spatial task (Picture Completion) was near zero (indeed slightly negative). These two correlation coefficients were significantly different from one another, $t(25) = 2.28, p < .05$. The tasks tapping both language and spatial ability were not correlated with social eye gaze performance or with control eye gaze performance.

Table 6 reveals a different pattern for the MLD children. First, the Picture Completion subtest measuring spatial ability correlated with verbal performance on the social tasks. We compared the correlation between spatial ability and social verbal performance in the MLD group to that in the autistic group using Fisher’s $r$ to $z$ transformations. The difference between the two correlation coefficients was marginally significant, $z = 1.80, p < .08$. Second, Picture Completion and the language composite also correlated with eye gaze on the social tasks. However, in this case there was no significant difference between this correlation in the MLD and autistic groups. Consistent with the results for the autistic group, eye gaze on the control task was not related to language or spatial ability. Our interpretation of this finding is that there was no correlation because children failed the eye gaze measure in the control task for reasons other than a genuine lack of understanding (see below).

**Discussion**

We found no difference in performance on the verbal questions between children with autism and MLD children on either the social tasks or the control task that tapped understanding of probabilities. Likewise, there was no difference in eye gaze in the two groups on the control task. The only measure that differentiated the two groups was the eye gaze measure in the social tasks, where children with autism were significantly less likely to look at the correct location than MLD children. Thus, even when there is no difference in the verbal performance of children with autism and children with MLD, there may still be a fundamental lack of social insight in autistic individuals. In addition, we showed that within the autistic group, the children whom teachers rated as having the most severe autistic characteristics were also the least likely to look to the correct location. One point of note is that our tasks did not tap metarepresentational insight as construed by Perner (1991), and didn’t even necessarily tap knowledge about mental states. The pattern of eye gaze in children is consistent with the idea that children with autism may have deficits in social understanding that extend beyond their ability to represent mental states (see the nonverbal measures discussed at the outset), but inconsistent with the idea that their deficit is solely in understanding representational mental states (Baron-Cohen, 1996; Frith, 1989; Leslie, 1987).

One argument against our claims is that children with autism were simply distracted at the time the eye gaze prompt was administered. This explanation leaves unexplained (a) why they weren’t equally distracted at the time of the eye gaze prompt in the control condition, (b) why they looked at either of the two locations (rather than away) in equal amounts to the children with MLD, and (c) why children with autism did not get lower scores on the verbal measures of the social and control tasks, a predictable consequence of general distractibility. Another argument might be that eye gaze differences in autism signal something other than a deficit in social understanding (e.g., stereotypes, preoccupations with parts rather than the whole, language abnormalities). Note that this kind of argument could be applied equally to all previous demonstrations of a verbal social deficit in autism. However, it is unclear why such symptoms should cause differences specifically in social eye gaze but not nonsocial eye gaze unless it is the social aspect. Second, whereas it is easy to see how a social deficit would lead to a different pattern of eye gaze on a social task, there is at present no clear theory of how stereotypes or preoccupations with parts would lead to this pattern of eye gaze. Third, general appeals to language do not seem a valid explanation because: (a) the two groups were equated for language, and (b) we would expect a language deficit to result in impaired verbal performance but it did not.

Our findings make perfect sense if eye gaze taps an insight that is more at the core of social understanding than explicit verbal measures. Primates and human infants do not have language but they do have social insights and the reliance on verbal measures would clearly be an inappropriate means for assessing their social understanding. We think that behavioral measures will often be more appropriate for children as well. This is not to say that verbal measures have no value, that children

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**Table 6**

| The Relation between Language, Spatial IQ, Social Understanding, and Control Task Performance |
| --- | --- | --- |
| Social: eye gaze | Social: verbal | Control: eye gaze |
| **Children with autism** | | |
| Language | .10 | .42* | -.06 |
| Spatial: Picture Completion | .20 | -.04 | .03 |
| Social: eye gaze | — | .12 | -.20 |
| Social: verbal | — | — | .05 |
| **Children with MLD** | | |
| Language | .37* | .46** | -.02 |
| Spatial: Picture Completion | .34* | .42* | -.14 |
| Social: eye gaze | — | .28 | -.34* |
| Social: verbal | — | — | -.06 |

*p > .05; **p < .01.
with autism will show a different pattern on all social behavior tasks, or that every autistic child will show a different pattern.

Our results are not easily explained by executive function accounts of autism (e.g., Hughes, Russell, & Robbins, 1994; Ozonoff, Pennington, & Rogers, 1991; Russell, Saltmarsh, & Hill, 1999). These accounts hold that children with autism fail theory of mind tasks because of the executive demands made by such tasks. For instance, children must inhibit what they know to be true to assign a different belief to a story character. One problem for the executive account is that, in the Statement-Behavior task at least, children did not need to inhibit what they knew to be true. A second problem is that in both social tasks most children with autism did not look to the correct location but their performance on verbal questions was equal to children with MLD. Executive demands are mainly or exclusively relevant to conscious, verbal understanding (Baddeley, 1976). Indeed, adults with executive function deficits tend to have intact implicit understanding (Shimamura, Gershberg, Jurica, & Mangels, 1992). If the eye gaze measure has a larger implicit component than the verbal questions (Ruffman et al., in press), then the executive argument should hold that eye gaze would be better than verbal performance, yet we did not find this. Thus, although it is possible that children with autism do have executive function deficits, we think such deficits are an unlikely reason for their lack of looking to the correct location on the social tasks. (See Griffith et al., 1999, for similar arguments regarding verbal social insights.)

Our results are also relevant to the idea that children with autism either “hack” their way through theory of mind tasks such that task success is not indicative of genuine understanding (Frith, Morton, & Leslie, 1991, p. 436), or that they use verbally mediated routes but genuinely understand something about the social world (Happé, 1995). For instance, Frith et al. argue against genuine understanding because children with autism fail second-order theory of mind tasks, which they claim should be within their capabilities. We think this claim is problematic. Children with autism may fail second-order tasks because of the high demands they place on working memory. We see no reason for not crediting children with autism with genuine understanding. It is just that they do not possess a full understanding. That is, children with autism may tend to use exclusively verbal routes whereas other children also use a less conscious, more spontaneous strategy. We use the term “verbal” here loosely, and in order to be consistent with previous researchers. In reality, many children point rather than answer verbally when asked the verbal test questions. A more accurate description is likely that verbal questions tap explicit, conscious insights that can be differentiated from eye gaze, which is often likely to tap unconscious or implicit insights. At the very least, our results indicate that children with autism did not demonstrate the spontaneous expectations shown by MLD children in social tasks, although they show similar expectations in nonsocial tasks.

In contrast to the above claims, Bowler (1997) concluded that individuals with autism use the same mechanisms as other individuals for understanding social information. He gave participants stories and asked them questions either about characters’ mental states or about nonmental state information. Reaction time was used as a measure of mechanism, with different reaction times purportedly indicating different mechanisms. Bowler found that high-functioning autistic and Asperger’s adults had slower reaction times than normal adults on both the mental state and the nonmental state questions, and consequently, argued against the idea that autistic individuals use a different mechanism in understanding the social world.

We agree with Bowler (1997) that children with autism may have been using a similar mechanism on mental state and nonmental state questions. On both types of question children’s conscious verbally based knowledge was tapped in that they were asked directly about mental states or factual details in the story. Because both measures were tapping conscious understanding there was no difference in reaction times. Yet, we emphasize that notwithstanding Bowler’s results, children with low IQ and children with autism do probably utilize different mechanisms in understanding the social world. We think this because of the way eye gaze differentiated the autistic and MLD groups, the correlation between eye gaze and autism ratings, and because of the way in which general language ability correlated with verbal performance but not eye gaze in the autistic group.

Regarding the last point, we found that for the children with autism, language was not related to eye gaze on the social tasks but it was correlated with verbal performance. Further, the measure of spatial ability, Picture Completion, was not related to either eye gaze or verbal performance. This pattern of correlations is consistent with the idea that for children with autism, verbal performance really is mediated by a different means than eye gaze. It is consistent with the idea that success on social tasks in children with autism tends to be largely verbally mediated, unusually conscious, and logical, and looks like some kind of “mental arithmetic” (Bowler, 1992; Bruner & Feldman, 1991; Happé, 1995).

For the MLD children, a different pattern of correlations was obtained. Spatial ability correlated with performance on the social verbal measure, and language ability also correlated with social eye gaze although to a lesser extent than with the verbal measure. The pattern of correlations for MLD children suggests that general intellectual ability rather than language in particular may mediate performance on the social measures. Thus, the language data provides converging evidence for the notion that children with autism understand the social world by a different route.

Another finding was that even in the MLD group, eye gaze was not superior to verbal performance on the social and the control tasks. The finding for the social tasks is different to the results of Clements and Perner (1994), Garnham and Ruffman (2001), and Ruffman et al. (in press), that in normally developing children eye gaze in a false belief task precedes verbal performance. This pattern might have arisen because we gave children more tasks (six) than previous researchers, all of whom gave children two tasks. The increased number of tasks might have lessened the expectation that the stimulus would return (given that it did not return) and led to poorer anticipatory looking. Nevertheless, what is crucial here is that eye gaze on the social tasks but not the nonsocial tasks was still very good at picking up meaningful differences between the two groups and within the autistic group.

We have argued that the explicit understanding tapped by verbal questions may be more theory driven, and that eye gaze will often tap more intuitive and spontaneous
insights. Here we note that the nature of the insights conveyed in eye gaze is an open question. Perner (1996; Perner & Clements, in press) argued that eye gaze might be based on simulation (e.g., children imagine what they would do if placed in the position of the story character). For instance, an adult can experience a range of emotions and expectations when watching a film, just because it is a realistic portrayal of events. One’s insight about the story characters’ feelings in this case will often not be based on theories but on something akin to simulation. However, another possibility is that eye gaze is based on very rudimentary knowledge that is more like a theory (or a prototheory). Just as a series of letters elicits automatic processes of pattern recognition (reading), social interactions might also elicit automatic processes of pattern recognition (e.g., linking affirmative or negative statements from one person to the subsequent behavior of another person). These processes will then allow implicit (and sometimes explicit) understanding of what others will do, think, or feel.

In fact, our results are consistent with the idea that both processes may be involved in eye gaze. Children with MLD were less likely to look to the correct location in the control tasks than to give correct verbal answers, whereas eye gaze in the social tasks was equivalent to verbal performance. If eye gaze in the social tasks was partially indicative of simulation then the simulation would presumably be easier if there was a person to simulate. In the control condition there was no person at the center of events and, hence, no one to simulate. This may be why even the MLD children were less likely to look to the correct location in the control task than to give a correct verbal answer. Thus, eye gaze might be based on both simulation and on automatic processes of pattern recognition, with pattern recognition playing the major role for nonsocial insights and social insights also involving an element of simulation.

In sum, our results are consistent with the idea that children with autism lack the basic, spontaneous insights possessed by MLD children that are manifest in eye gaze. Instead, children with autism must rely on explicit theories that have been formed as the result of self-motivated induction, or explicit tutoring from parents or teachers. Our results are consistent with the idea that explicit theories are no substitute for the spontaneous insights possessed by MLD children in that children with autism who tend to lack these insights have more severe autistic symptoms.

Acknowledgements—Many thanks to Pete Clifton for providing the software to analyze looking times, and the Economic and Social Research Council for financial support (award #R000237322).

References


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Appendix A

Questionnaire Given to Nursery Workers

Please rate the child using the scale below:

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
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<th>All the time</th>
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<td>2</td>
<td>3</td>
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<tr>
<td>8</td>
<td>9</td>
<td>10</td>
<td></td>
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</tbody>
</table>

1. When interacting with another person, he/she is able to sustain eye to eye contact.
2. Uses facial expression to regulate interaction with another person.
3. Uses body expressions appropriately when interacting with another person.
4. Develops peer relationships appropriate to his/her developmental age.
5. Can spontaneously seek to share enjoyment with other people (e.g. by showing, bringing, or pointing).
6. Can spontaneously seek to share interests with other people (e.g. by showing, bringing, or pointing).
7. Can spontaneously seek to share achievements with other people (e.g. by showing, bringing, or pointing).
8. Participates in spontaneous make-believe play with others.
9. Participates in imaginative play with others.
10. Participates in simple social play with peers.
11. Participates in simple games with peers.
12. Has an understanding of other children’s needs.
14. Can gesture and/or mime to communicate with people.
15. Can use spoken language to communicate with people.
16. Can initiate conversation with other people.
17. Can sustain conversation with other people.
18. Demonstrates stereotyped and repetitive use of language.
19. When using spoken language he/she uses correct pitch, intonation, rate, rhythm, and stress.
20. Understands simple questions.
22. Understands simple jokes.
23. Has a preoccupation with one or more stereotyped and restricted patterns of interest.
24. Inflexibly engages in nonfunctional routines or rituals.
25. Has stereotyped and repetitive motor mannerisms (e.g. hand or finger flapping or twisting, or complex whole-body movements).
26. Has a persistent preoccupation with parts of objects.

Appendix B

Verbatim Procedure of Experimental Tasks

Desire-Behavior Task (Condition 1)

This is Charlie. Charlie is playing on the slides. When Charlie wants to look in the red box he slides down the red slide. When he wants to look in the green box he slides down the green slide. Look! Charlie slides down the red slide to look in the red box. He slides down the green slide to look in the green box.


Memory Check 1: Which food does Charlie like?

Charlie doesn't know where to put the fruit. "I know," Charlie says. "I'll put the apple in the red box and I'll put the orange in the green box." Charlie is tired now so he goes up the ladder and behind the box to his bedroom where he falls fast asleep.

Later on Charlie wakes up. He wants to get something to eat. I wonder which slide Charlie will come down. (Pause for 10 seconds)

Verbal Question: Which slide will Charlie come down?

Memory Check 2: Which fruit did Charlie like?

Memory Check 3: Where did Charlie put the apple?

If children answered this question incorrectly, the character's desires were repeated, and the memory question was asked again.

Statement-Behavior Task (Condition 1)

Training Phase: This is Sam. This is Sam's house. Sam goes into his house. Sam comes to a tree room and a flower room. First Sam goes into the tree room. I wonder which window Sam will go to?—Look! Sam looks out of the tree window. Then Sam goes into the flower room. I wonder which window Sam will go to?—Look! Sam looks out of the flower window. Sam goes back outside.

Here are two more houses. Look this is the white house and this is the orange house. This is Sam's dad. Dad is fixing a hole in the roof of the orange house. Sam asks Dad if he can look inside the white house. Dad says, "Yes, you can look in both of the rooms in the white house." Sam goes into the white house. Sam comes to a blue room and a yellow room. First Sam goes into the blue room. I wonder which window Sam will go to?—Look! Sam looks out of the blue window. Then Sam goes into the yellow room. I wonder which window Sam will go to?—Look! Sam looks out of the yellow window.

Experimental Phase: Sam asks Dad if he can look inside the orange house. Dad says, "One of the rooms in the orange house isn't safe." Sam goes into the orange house. Remember, Dad said that one of the rooms in the orange house wasn't safe. Sam comes to a red room and a green room. Sam doesn't know whether to go into the red room or the green room. He doesn't know which room is the safe room. He shouts out to Dad, "Dad, is the red room safe?"

LET'S SEE WHAT DAD SAYS. DAD SAYS "NO" (OR "YES").

Sam knows which room to go into now. Sam is a good boy and he always does what Dad says. Sam goes back into the orange house. He will go to one of the windows now. I wonder which window Sam will go to.

Verbal Question: Which window will Sam go to?

Control Task (Condition 1)

Check 1: Show me the ball.
Check 2: Show me the square.

This is Sam. Sam is playing on the slides. Sam takes a shape out of here (a container) and puts it in the chute at the back of the box. If it is a red square it will come down the red slide. If it is a green ball it will come down the green slide. Look! The red square comes down the red slide and the green ball comes down the green slide.

Check 3: Which slide would this one (the square) come down?

Check 4: Which slide would this one (the ball) come down?

In this game Sam won't tell you whether he has got a ball or a square. You have to guess what the shape is. Look in here.

There are 10 squares and no balls. Sam takes a shape out of here, he says "I will put the shape down the slide now." I wonder which slide the shape will come down. (Pause for 10 seconds)

Verbal Question: Which slide will the shape come down?

Test and memory questions are in italic. The experimenter's interjections are in capitals. All other text was narrated on audiotape.