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The role of eye contact in goal detection: Evidence from normal infants and children with autism or mental handicap

WENDY PHILLIPS,[a] SIMON BARON-COHEN,[b] AND
MICHAEL RUTTER[a]
Departments of [a]Child and Adolescent Psychiatry and [b]Psychology, Institute of Psychiatry, University of London

Abstract
One reason for looking at a person's eyes may be to diagnose their goal, because a person's eye direction reliably specifies what they are likely to act upon next. We report an experiment that investigates whether or not young normal infants use eye contact for this function. We placed them in situations in which the adult's action toward them was either ambiguous or unambiguous in its goal. Results showed that the majority of normal infants and young children with mental handicap made instant eye contact immediately following the ambiguous action but rarely after the unambiguous action. Young children with autism, in contrast, made eye contact equally (little) in both conditions. These results are discussed in relation to the function of eye contact, to our understanding of infant cognition, and to the theory of mind hypothesis of autism.

Premack (1990) argued that understanding of intention is hard-wired into infants: "When a self-propelled object changes its motion without assistance from another object, the infant's principal hard-wired perception is intention" (p. 1). Premack used the term intention to mean, on the one hand, self-propulsion/goal-directedness and, on the other, the mental state of intention, as the following two quotations make clear:

> . . . the infant perceives one object as having a goal. (p. 7)

> The infant's concept of intention differs visibly from that of the adult or common sense. The infant's concept is an automatic reading of a perceptual input, loosely interpretable as "*internally caused.*" For the infant, objects are intentional (or have intention) when their movements are self-propelled. Whereas for common sense, intention is not an automatic reading of a perceptual input, but an *inferred state of mind* based on evidence for desire, belief, and planning. (p. 12; emphasis added)

Premack's claim, then, is that infants understand that objects can be self-propelled and goal-directed. This is similar to what Mandler (1991) described. Only later (by 3 or 4 years old) might we expect children to understand intentions as mental states (Astington & Lee, 1991). In this paper, we focus on Premack's claim about infancy and set out to investigate further the suggestion that infants as young as 9 months of age may understand that people's actions have

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goals. By a goal, we mean the target of a person's action.

In the experiment reported here, we make the assumption that infants (and others) can derive information about a person's goal by monitoring the direction of the person's gaze (Baron-Cohen, in press). Gaze direction tells us not only where a person is looking, and thus what the person is interested in (or is attending to), but also what the person is likely to act upon next. In this simple way, infants may use gaze direction as a primitive psychology with which to make sense of past actions and predict a person's next action, prior to using a more sophisticated belief-desire psychology, or theory of mind (Baron-Cohen, in press).

We describe an experimental situation that tests if infants do use eye contact (or more precisely, gaze monitoring) for this specific function. Throughout this paper, we use the terms *eye contact* and *gaze monitoring* interchangeably to mean looking at a person's eyes—and this need not be mutual. Although there are likely to be many different functions of eye contact (Argyle, 1972; Rutter, 1984), we are interested here only in the goal detection function. The experimental situation we employed investigates how infants use gaze when an adult's action is ambiguous. A second aim of the study was to investigate whether or not children with autism, who are reported to show abnormal eye contact (Kanner, 1943; Mirenda, Donnellan, & Yoder, 1983; Volkmar & Mayes, 1990), use eye contact for this function, namely, to detect a person's goal. Finally, we wanted to check whether or not goal detection was normal in children with mental handicap but with a mental age at a similar level to or greater than our normal sample.

We used two tests of goal ambiguity, derived from the clinical and developmental literatures. The first, which we call the Blocking Test, derives from longstanding clinical observations.[1] Essentially, the test involves blocking the child's action unexpectedly, by the adult placing his or her hands over the child's hands. This leads, clinicians attest, to the normal child making instant eye contact. To date, this test has not been used systematically with young normal children.

The second test of goal ambiguity derives from Reddy's (1991) naturalistic studies of "mucking about" by infants around 9 months of age. One phenomenon she documented is teasing, between adult and infant. Her example of teasing is when the adult (or child) offers an object, but then withdraws it, laughing. She claimed that "early understanding of others' teasing consists of distinguishing between serious and non-serious intentions" (p. 154). From our earlier discussion of the term *intention* in infant comprehension, it is clear that we prefer the term *goal*. Again, like the Blocking Test, the Teasing Test has not been subjected to systematic examination, so we set out to do this in our experiment.

We were also interested in testing whether young normal infants only use eye contact to understand ambiguous action, or such eye contact plays an important role in understanding unambiguous actions too. Accordingly, we tested each group using an unambiguous action, namely giving.

Subjects

We tested three groups of subjects. First, we chose a sample of normal infants, aged 9–18 months (M = 14.2 months, SD = 2.7 months). These were tested with their caregiver present, because they were not yet old enough to be tested alone. Second, we tested a group of young children with autism, aged 3–5 years (M = 53.3 months, SD = 10.9 months), all of whom met conventional diagnostic criteria (American Psychiatric Association, 1987; Rutter, 1978). They were seen either in an under-5s creche run by the National Autistic Society or in their nursery class at a special school for children with autism or at home. Diagnoses were made in five centers in Britain well known for expertise in this area and using systematic assessment methods. Two children diagnosed as only having "autistic fea-

1. We are grateful to Christopher Gillberg for suggesting we use this clinical test experimentally.

tures" were excluded from the study. While the group with autism were older than the normal group, they had a mental age that went as low as that of the normal group. Mental age was assessed using nonverbal items of either the Merrill–Palmer or, where that could not be used, the Bayley Scales of Infant Development. This mental age testing was carried out on a later visit, within a few months of the experiment.[2]

Finally, we tested a group of young children with mental handicap, who were comparable to the children with autism in terms of both chronological and mental age. This group contained six children with Down syndrome, one with tuberous sclerosis (but without autism), and one with hydrocephaly. The remaining subjects in this group had mental handicap of unknown etiology. All the subjects with mental handicap were attending schools or nurseries for children with general learning difficulties and were the subjects of Statements of Special Educational Needs by local authority education departments. The details of the subjects are shown in Table 1. All three subject groups were of mixed socioeconomic class, predominantly white, and although the normal group contained roughly equal numbers of males and females (10 males : 8 females), the sex ratio in the group with autism was 18 males : 0 females, whereas of the group with mental handicap it was 11 males : 7 females.

Subjects were seen at home or at school. In Conditions 1 (teasing) and 2 (blocking), each group contained 18 subjects. In Condition 3 (giving), data for five subjects (four with autism and one with mental handicap) were missing, because, for a range of reasons, the experiment could not be continued.

2. Both scales were used as measures of approximate nonverbal mental age, by means of omitting the verbal items. In the case of the Merrill–Palmer test, omitted verbal items were credited as passed, in accordance with the standard scoring instructions. This ensured that the estimate of nonverbal mental age was not unfairly depressed by the omission of verbal items. The standard method of scoring the Bayley Scales does not allow for a similar adjustment to be made for omitted items. Nevertheless, the mental age scores produced are unlikely to be misrepresentative, because only four children (three with autism and one with mental handicap) were tested with this instrument, and these children were functioning at a level below that at which verbal items feature in the Bayley Scales.

Method

The blocking task

The child was encouraged to play with a variety of toys. When the child was manually and visually engaged with a toy, the experimenter covered the child's hands with her own hands, preventing the child from further activity, and then held this block for 5 s. The child's gaze behavior was noted during this 5-s period, as were his or her other responses to this block. This was repeated 3 more times.

The teasing task

The experimenter offered the child a toy. When the child looked at the toy and began to reach for it, a trial began. As the child reached for it, the experimenter withdrew it and held it out of reach for 5 s. Then she gave the child the toy. Again, the child's gaze behavior and other responses were noted. This was also repeated 3 more times.

The giving task

Whereas the previous two tasks presented ambiguous actions, this control task, the giving task, used an unambiguous action, giving. As mentioned earlier, this was included to test whether all actions were as likely to elicit eye contact, or (as we predicted) ambiguous actions would elicit eye contact more often than unambiguous ones, since the goal of the person needed checking. The giving task simply consisted of the adult offering the child a toy, either holding it out or placing it on the floor directly in front of the subject. This was repeated during the session and took place after a clear separation from the previous conditions.

Table 1. *Subjects' chronological and mental ages (in months)*

Groups		Chronological Age	Nonverbal Mental Age[a]
Normal (n = 18)	*M*	14.2	–
	SD	2.7	
	Range	9–18	
Autism (n = 18)	*M*	53.3	38.5
	SD	10.9	17.4
	Range	36–70	12–66
Mental handicap (n = 18)	*M*	60.4	38.3
	SD	11.7	14.4
	Range	40–86	19–73

[a]Merrill-Palmer, or Bayley.

Giving was chosen as an example of an unambiguous action because it is so commonplace that the infant could code the goal of the action simply by tracking the trajectory of the adult's hand passing the object. Being such an everyday action, the infant could use gaze monitoring but need not do so. In comparison, we predicted that ambiguous actions would necessarily require eye contact for the infant to detect the adult's goal. Again, a 5-s time period was used as the observation period in which eye contact had to appear.

Coding and Reliability

Coding of eye contact was initially performed in "real time" by the experimenter, on the grounds that, because she was interacting with the child and it was eye contact with her that was being measured, she was the only person who could tell if unambiguous eye contact had been made. However, to test reliability, we videotaped the testing of the two clinical groups. On these occasions, the experimenter announced when a trial began and then announced whether or not she had received eye contact during the 5-s time window following the key action. The length of eye contact was unimportant, so long as it was considered unambiguous. A second rater than watched the videotapes of all the clinical subjects (n = 34, because for 2 subjects with mental handicap, the film was not clear enough to code), coding just the first trial of the teasing task for each subject. This was done as follows: After the experimenter's announcement of the beginning of a trial, the second rater turned off the sound and then scored whether or not the child's line of regard shifted toward the experimenter's face, during the subsequent 5 s. This second rater was blind both to the diagnosis and to the hypotheses of the study. Over the 34 data points, agreement was 94%. Cohen's (1967) kappa coefficient was 0.87, which represents an acceptable level of agreement.

Results

The results are shown in Table 2 and Figure 1. Table 2 shows the percentage of each group that looked at the experimenter's eyes immediately after either the tease (Condition 1), the block (2), or the give (3). Our criterion was that the child had to make eye contact during the 5-s period on at least half of the trials (Figure 1). As can be seen, using this criterion, all of the normal infants made eye contact immediately following the tease or the block, but only 39% of them did so immediately following the give. The children with mental handicap showed a similar pattern, although this was clearer in the tease condition than in the block. In contrast, less than 11% of children with autism made eye contact with the experimenter immediately following the block or the tease, and 7% did so following the give.

Chi-square tests on the number of subjects in each group passing each condition

Table 2. *Percentage of each group who made eye contact with the experimenter on at least half of the trials, within 5 s of the tease, block, or give*

Groups	Conditions (1) Tease[a]	(2) Block[a]	(3) Give[b]
Normal	100%	100%	39%
Mental handicap	78%	56%	12%
Autism	6%*	11%*	7%

[a]n = 18 in each group. [b]n = 17 in mental handicap group; n = 14 in autism group.
*Autism × Mental Handicap, $p < .005$, Fisher's exact probability test.

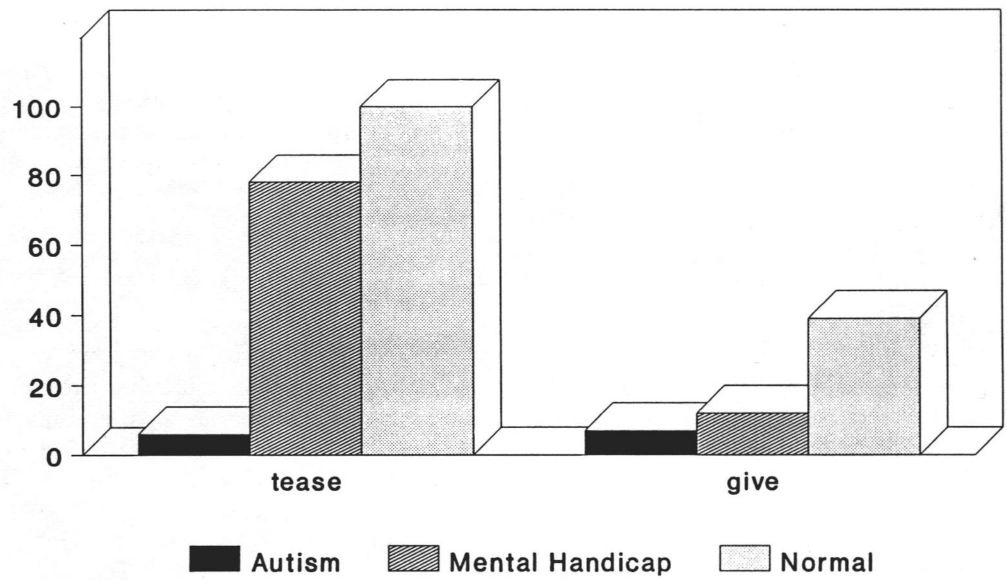

Figure 1. Goal detection task: percentage of children making eye contact within 5 s (on at least half the trials).

showed the following results: on tease, $\chi^2 = 36.94$, 2 df, $p < .001$; on block, $\chi^2 = 28.8$, 2 df, $p < .001$; on give, $\chi^2 = 4.36$, 2 df, $p < .113$. Posthoc testing showed that all three groups differed from one another on tease and block, but none of the groups differed on give.

Thus, on the block and tease conditions (but not the give condition), the rate of eye contact by the children with autism was significantly lower than in either of the other two groups. The children with autism who did not look at the experimenter's eyes after the block or the tease instead either attempted to remove the experimenter's hands from blocking theirs or pursued the object being teasingly withdrawn. The group difference between the children with autism and mental handicap on the Teasing Test was also found by the second rater (who was blind to the groups and to the hypothesis) in proportions very similar to those of the first rater: 2 out of 17 versus 10 out of 16, as compared to 2 out of 18 and 11 out of 18. This group difference from the second rater was statistically significant (Fisher's exact probability test, $p < .05$).

This analysis suggests there is a Group × Condition interaction, in that only the group with autism showed a similar re-

Table 3. *Mean number of eye contacts by each group, in each condition*

Groups		Conditions (1) Tease[a]	(2) Block[a]	(3) Give[b]
Normal	*M*	3.44	3.11	0.44
	SD	0.7	0.83	0.7
Mental handicap	*M*	2.29	2.12	0.12
	SD	1.36	1.62	0.33
Autism	*M*	0.57	0.64	0.07
	SD	1.09	0.93	0.27

[a]n = 18 subjects in each group; maximum number of eye contacts = 4, because there were four trials. [b]n = 17 subjects in mental handicap group; n = 14 subjects in autism group; maximum number of eye contacts = 2, because there were two trials.

sponse across all conditions. To test for an interaction of this kind, we calculated a new variable, called the difference between conditions scores. These scores were derived from actual scores, taking the difference between tease versus give and block versus give, respectively. A Kruskall–Wallis test on these difference between conditions scores confirmed the significant effect of group for both the tease versus give score ($\chi^2 = 20.51$, $p < .001$) and the block versus give score ($\chi^2 = 16.25$, $p < .003$). Posthoc tests, using Nemenyi's procedure, showed that the only significant group differences on these difference between condition scores were between the children with autism and the other two groups ($p < .05$). Finally, a multivariate analysis of variance, performed on actual scores, confirmed the highly significant Group × Condition interaction, $F(4, 92) = 9.36$, $p < .001$. The actual scores (means and standard deviations) from each group are shown in Table 3.

To summarize, the normal children and those with mental handicap looked significantly more in the ambiguous (tease and block) conditions than in the unambiguous (give) condition, whereas the children with autism made eye contact with similar (low) frequency across all three conditions.

Effects of mental age

In the group with mental handicap, the passers and failers did not differ in terms of mental age (blocking, $t = 1.95$, 16 df, $p = .07$; tease, $t = 0.2$, 16 df, $p = .8$). For the group with autism, a similar analysis could not be performed, because there were so few passers.

Baseline eye contact

All but two of the clinical subjects were filmed with their parent or caregiver for a 2-min period, to establish baseline eye contact. This was to rule out an eye contact avoidance hypothesis. This showed that 12 out of 16 subjects with autism (or 75%) made eye contact at least once, as did 100% of the group with mental handicap.

Discussion

The data are very clear. Both tests show that all of our normal infants, from 9 to 18 months,[3] responded to the teasing and blocking task by instantly establishing eye contact with the experimenter. So did the majority of children with mental handicap. This effect was most clear on the teasing task but was still robust on the blocking task. In contrast, most children with autism, with an equivalent mental age, did not make eye contact as often with the experimenter during the critical periods. Instead,

3. Our pilot data with normal children with a broader age range (6–33 months, n = 15) showed a very similar pattern.

they looked at the experimenter's hand, or at the toy, and in the blocking test simply tried to remove the hand obstructing their own. This echoes Kanner's (1943) early description of autism: "He never looked up at people's faces. When he had any dealings with persons at all, he treated them, or rather parts of them, as if they were objects" (Kanner, 1943, reprinted in 1973, p. 15).

Why do normal infants look at the adult's eyes precisely in this 5-s time window? (Incidently, 5 s was allowed as a generous measure: In practice, if a child established eye contact following the tease or the block, this was usually instantaneous—within 1-2 s.) At the outset of this paper, we argued that this was because, faced with ambiguity in the adult's action, they sought to clarify the adult's goal by checking the direction of the adult's gaze, the latter being a reliable clue to the former (Baron-Cohen, in press). While this is not the sole function of eye contact, we believe it may be an important one. We suggest that the data from the unambiguous action control condition (giving) confirm that such eye contact is used far more frequently to clarify ambiguity in a person's action.

It may of course have been that normal infants made eye contact not to check the experimenter's goal ("What are you trying to do?") but, rather, to signal their own intent ("Get off!" or "Give me that!"). However, the eye contact did not appear to be requestive in that it was never accompanied by requestive gestures, vocalizations, or imperative utterances (in those subjects with language). Similarly, in the older verbal normal children in our pilot study, requests were never voiced. Rather, the eye contact was accompanied by silence and appears to us to be a search for the goal behind the action.

A final reason for believing that the child was seeking information about goals and not making a request is that our results contrast markedly with those reported by Mundy, Sigman, Ungerer, and Sherman (1986), who explicitly used a situation designed to elicit requests (putting a toy out of reach, or letting a wind-up toy wind down). They found that young children with autism did not show less eye contact than controls. This strikes us as strong evidence that children with autism are likely to look up at the face to request but rarely do so to search for an adult's goal.

How might goal detection differ from emotional referencing (Feinman, 1982)? Emotional referencing may share something in common with the goal detection phenomenon in that both are triggered by forms of uncertainty, but there are also reasons for believing that they are separable phenomena, and that our tests were eliciting goal detection rather than emotional referencing. One reason for arguing this is that during emotional referencing, we assume the child would usually seek eye contact with their caregiver (if he or she was present), presumably to search the caregiver's face for signs of emotional reassurance or warning. In contrast, during goal detection, eye contact is always directed toward the person who is the source of the ambiguous action, even when this is a strange adult and the mother is present. This was borne out by the normal infants, who first made eye contact with the experimenter immediately after the ambiguous action, despite their mothers being in the room with them. We do not wish to rule out the possibility that emotional information plays a role in this phenomenon, but this remains to be clarified.[4]

An alternative explanation for the lack of eye contact by the children with autism in these tests might be that they prefer to avoid eye contact (Bettelheim, 1967; Richer, 1978; Tinbergen & Tinbergen, 1983). This expla-

4. There is an interesting issue to be untangled here: How does goal detection differ from emotional referencing? This is in part a definitional issue: Emotional referencing entails seeking information about emotion, whereas goal detection involves seeking information about goals. We assume that both phenomena are part of social referencing, in being directed toward a person. Testing whether or not goal detection and emotional referencing can take place independently is an important next step for research in this field, because this will help sort out if the deficit underlying the lack of eye contact by children with autism in this experiment is due to a lack of sensitivity to a person's goals or their affect.

nation seems unlikely: First, our baseline eye contact data collected before the experiment showed that when each child in the two clinical groups was filmed for a 2-min period in the presence of their mother or caregiver, 75% of the children with autism (and 100% of the children with mental handicap) showed eye contact. In addition, other studies (Hermelin and O'Connor, 1970; Sigman, Mundy, Ungerer, & Sherman, 1986) also show that children with autism do not avoid eye contact. Rather, they appear not to use it for the same purposes as nonautistic children.

Finally, we consider it unlikely that eye contact is a random event for normal or mentally handicapped infants. In our experiment, the timing of the eye contact, when it came, was very precise and always followed the "trigger" of an ambiguous action. It is in this sense that we argue, along with social psychologists, that eye contact has functions (Argyle, 1972). Testing that it was eye *direction*, rather than other information conveyed by the eyes, that the normal infants were using in the goal detection function, requires disentangling in further studies.

In conclusion, we argue that our data support Premack's (1990) contention that, at least by 9 months of age, normal infants understand that people are goal-directed in their action. So do young children with mental handicap. In contrast, young children with autism appear delayed or impaired in this ability. Because children with autism show severe deficits (later in development) in understanding the mental states of believe, know, and pretend (i.e., they lack many components of the normal theory of mind [Baron-Cohen, in press]), it may be that their apparent failure to use eye contact to diagnose a person's goal reflects an abnormality in an important early precursor in the development of a concept of mind (Baron-Cohen, 1991). Testing this precursor hypothesis is a task for the future. As with other studies that have examined autism, this population may hold a key to enable investigators to unravel what is necessary for normal development to occur and serve as an illustration of the value of adopting the perspective of developmental psychopathology (Cicchetti, 1990).

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