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Autistic children's understanding of seeing, knowing and believing

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In this study we establish that autistic children have severe and specific difficulty with understanding mental states. Even with a mental age of 7 years, these children mostly fail in tasks which are normally passed around age 3 and 4. We confirm previous results on the poor understanding of *false belief* but also find that autistic children's grasp of the notion of *limited knowledge* is grossly delayed. We rule out various other explanations for these results and further show that the autistic child's performance is not limited by failure to understand the causal notion of *seeing*. Likewise, memory failure cannot be blamed. Language delay can be ruled out as a cause of failure since a group of children with specific language impairment, matched for verbal mental age, performed at ceiling. We propose that autistic children are specifically impaired in their meta-representational capacity and that this impedes their construction of a 'theory of mind'.

Since the pioneering work of Hermelin & O'Connor (1970) the search has been on for a *basic cognitive deficit* in autism. The aim of this project is not simply to explain the intellectual capacities of autistic children but also the peculiarities of their social and affective development.

The challenge of this search is twofold: first, to identify a cognitive mechanism underlying normal social development which appears to be impaired in autism; second, to understand the nature of the impairment in this mechanism and how this may lead to autism. In the long term the success of this search should culminate in an explanation of the pathogenesis of the classic symptoms of autism.

In 1985 we made the suggestion that the relevant normally developing mechanism is one for creating and handling *meta-representations* (Baron-Cohen, Leslie & Frith, 1985). We proposed that the basic cognitive deficit in autism stems from the dysfunction of this mental capacity. Meta-representation stands to representation as knowing about knowing stands to knowing. Leslie (1987, 1988*a*, *b*) argues that a capacity for meta-representation spontaneously develops towards the end of the second year of a normal child's life. This capacity is manifest in the simultaneous appearance of the ability to pretend and to share pretence with others. Leslie's model of this cognitive ability traces a logical connection between early appearing pretence and the later development of a *theory of mind*. It is well documented that autistic children have serious impairments in pretend play (Baron-Cohen, 1987; Rutter, 1978; Sigman & Ungerer, 1981; Ungerer & Sigman, 1981; Wing, Gould, Yeates &

Brierley, 1977; Wulff, 1985). On the basis of the postulated connection, we predicted impairment in their theory of mind.

By theory of mind we mean the ability to take account of one's own and others' mental states in understanding and predicting behaviour. To understand what someone expects or believes can be much more important than taking into account physical circumstances. For example, Sally hides a marble in her basket. She then goes out for a walk. Meanwhile, Ann transfers Sally's marble from the basket to a box. When Sally returns from her walk she wants her marble—but where will she look for it? We know where—in the basket—because we take account of Sally's mental state, and we are undeterred by the physical presence of the marble elsewhere.

The above scenario formed the basis of the study reported by Baron-Cohen *et al.* (1985). Dolls were used to portray the protagonists and the events to three groups of children. The first group were clinically normal 4-year-old children of whom 85 per cent correctly predicted where Sally would look on the basis of her now false belief. The second group were severely retarded Down's syndrome children of whom 86 per cent also correctly predicted Sally's behaviour. The third group were relatively able autistic children of whom only a meagre 20 per cent were able to predict Sally's behaviour in line with her belief. This result confirmed our prediction and supported the idea that autistic children were *specifically* impaired in their theory of mind. We said 'specific' because their failure could not be explained by general mental retardation.

Subsequently, using a picture sequencing task, we showed that the specificity of the autistic children's impairment could be defined more precisely (Baron-Cohen, Leslie & Frith, 1986). Their performance on both physical–mechanical and social–behavioural events was extremely good in contrast to their performance on events which crucially involved the protagonist's beliefs. This pattern also showed up in their verbal descriptions of the stories and was quite distinct from the pattern of performance shown by the normal 4-year-olds and by the severely retarded Down's syndrome children.

These two studies indicated that autistic children are impaired in a major aspect of theory of mind, namely, understanding *false beliefs*. It is still necessary to show that they would also be impaired in understanding other mental states, such as knowledge (true belief) and ignorance. If this were so, it would strengthen the case that the cognitive deficit in autism has to do with mechanisms for forming and handling meta-representations. Since meta-representation plays an important role in many aspects of communication and social competence (Leslie, 1987, 1988*a*; Sperber & Wilson, 1986), such a cognitive deficit may have a direct connection with the major symptoms of autism. However, as Leslie & Frith (1987) point out, there are still many questions which have yet to be investigated before this idea can be worked out and supported in detail.

One of our aims was to replicate the results of Baron-Cohen *et al.* (1985) with different autistic children. We also wanted to see if the same results could be obtained using real people to act out a real scenario rather than using dolls to depict the events. This will remove any possible disadvantage the autistic children may suffer if using dolls requires them to pretend.

Another aim was to refine our autistic sample with respect to verbal mental age

(MA): since up to age 4 false belief tasks can be difficult for normal children, we wished to include only autistic children whose MA exceeded 4 years 5 months. This was the average chronological age of the normal children in the original experiments. Autistic children typically show non-verbal MAs which are substantially higher than their verbal MAs. Our criterion based on verbal MA then is, if anything, rather conservative with respect to their general level of intellectual functioning and may underestimate it.

It is true that the understanding of false belief is difficult to test without using language. Even though we have a stringent criterion for minimum verbal mental age, we may still overestimate the linguistic capacity of the autistic children. Our fourth aim therefore was to use children with specific language impairment (SLI) as a control group. These children all suffered from severe difficulties in language comprehension and attended a special school. We matched them with our autistic sample on verbal MA. A consequence of this matching procedure was a difference in terms of verbal IQ. Our previous results (Baron-Cohen *et al.*, 1985, 1986) suggest that level of IQ is not relevant to our tasks because severely retarded Down's syndrome children outperform more intelligent autistic children. In any case, on a non-verbal IQ test our autistic children would score in the normal or borderline range of intelligence.

Our main aim was to extend our investigations beyond the concept of false belief. Although it may be somewhat easier to employ the notion of true belief than false belief, Hogrefe, Wimmer & Perner (1986) found that the concept of knowledge and ignorance is not in the grasp of most normal children until nearly 4 years of age. It thus appears only slightly earlier than understanding false belief. There is evidence that it is not until around 4 years that normal children acquire a *causal* understanding of how such meta-representational states arise (Leslie, 1988*a*; Wimmer, Hogrefe & Sodian, 1988; Perner & Ogden, 1988). This would apply equally to the concepts of limited knowledge and false belief. According to our hypothesis of a meta-representational deficit, we expect autistic children's understanding of both concepts to be poor. On the other hand, since normal children show a slight advantage for limited knowledge tasks, this might also be the case for autistic children.

Of course, we wished to test not merely the comprehension of the lexical item 'know', but also the ability to predict behaviour taking into account what someone knows or does not know.

Lastly, we wanted to test separately autistic children's ability to remember location of an object and their understanding of the concept seeing/not seeing. These abilities play an important role in our mental state tasks and therefore we wished to find out whether they would present any problems in their own right.

The concept of seeing/not seeing need not be thought of as a mental state concept. Instead, it could be a purely geometric–causal notion involving the construction of an imaginary line in space between the eyes and their target. If this line is not blocked by any other object then 'seeing' occurs; if an unblocked line cannot be constructed, then 'not seeing' results. This is strikingly similar to the requirements of various causal problems which 2-year-olds also solve by this means (Shultz, 1982). This would explain why very young children can understand it so early and why congenitally blind children have no problems either (Landau & Gleitman, 1985). A geometric–causal notion does not require knowledge of the *experience* of seeing.

Normal children appear to understand line of sight around 2 years of age (Masangkay, McCluskey, McIntyre, Sims-Knight, Vaughn & Flavell, 1974; Flavell, Abrahams, Croft & Flavell, 1981). Hobson (1984) also found that autistic children perform on visual perspective taking tasks as well as their MA permits. There is reason then to expect that able autistic children will understand line of sight even if they cannot cope with mental state concepts.

Method

Subjects

We tested 18 autistic children who came from two special schools in London and were diagnosed according to criteria specified by Rutter (1978). There were 15 boys and 3 girls. We also tested 12 children with specific language impairment (SLI) consisting of 9 boys and 3 girls who all attended a special school. Both groups were assessed for verbal MA with the British Picture Vocabulary Scales. Details are shown in Table 1.

Table 1. Subjects' background variables (verbal MA and CA)

	MA		CA	
	Mean	Range	Mean	Range
Autistic ($n=18$)	7:2	4:5–12:8	13:10	7:1–18:6
SLI ($n=12$)	6:9	5:5–8:7	8:8	6:11–9:11

Note. Ages are in years:months; MA is based on BPVS scores.

Procedure

Four tasks were carried out with 14 of the autistic children in the following fixed order: line of sight, memory for position, limited knowledge and false belief. All 18 children took part in the last two tasks and the SLI children took part only in the false belief task. We chose a fixed order because we presumed that the tasks increased in difficulty and that the more difficult tasks would therefore receive the benefit of some familiarity. Different materials were used in different tasks to minimize interference.

Line of sight. For this test we used a doll, except for those children who rejected the idea that a doll could see, in which case one of the experimenters took the place of the doll. A plastic board was placed on the table between experimenter and child, perpendicular to the child. The doll could be on either side of the board, always visible to the child. A counter was introduced and placed on one side of the board. The child was then asked whether the doll could see the counter. Depending on the position of the counter in relation to the doll and board, the correct answer was either yes or no. This was repeated five times varying the positions of both counter and doll. For three of the five trials the correct answer was 'yes'. Subsequently a further three trials were given in which the experimenter varied the position of the doll while the child was handed the counter and asked to place it where the doll could (one trial) or could not see it (two trials).

Memory for position. Three differently coloured hiding places (egg boxes) were introduced to the child and spread out on the table. Experimenter 2 showed the child a marble and said, 'I am going to hide the marble under the blue box. Will you help me remember where I put it?' Experimenter 2 then left the room. While she was out experimenter 1 removed the marble from the blue box and played with it for a few seconds before handing it to the child saying, 'Will you put it back where [experimenter 2] put it before?' This request tested non-verbally the child's ability to remember the original location. Experimenter 2 was then called back and the child was asked, 'Where did [experimenter 2] put it?' This question was the same as that asked in the subsequent tasks.

Limited knowledge. Three new hiding places were introduced to the child: a round brown container, a square yellow box, and a red purse. Experimenter 1 then introduced a red counter to the child saying, 'Look, I have a red counter'. The experimenter than proceeded to hide the counter under the yellow box slowly and deliberately, asking the child and experimenter 2 in turn, 'Can you see me hiding this counter under here?' Experimenter 2 made a point of agreeing that she could indeed see the counter going under the yellow box. Having completed this hiding, ensuring that the child attended both to the place of hiding and to the fact that experimenter 2 could see this, experimenter 1 asked experimenter 2 to leave the room for a minute. While she was outside, experimenter 1 drew the child's attention to the fact that experimenter 2 was no longer in the room and could not see what they were doing. Then experimenter 1 produced another identical counter and showed this to the child saying 'Look, I have another counter'. This was then given to the child with the request, 'Can you put it somewhere different?' (control question 1). All children were successful at choosing a hiding place different from the previous place. This demonstrated indirectly memory for the original location. The child was then asked, 'Where did [experimenter 2] see me hide a counter?' (control question 2). The response here had to be correct or else the task was repeated. After the child's correct response, experimenter 1 pointed to the place where the child had hidden the second counter and asked 'Does [experimenter 2] know that there is a counter under here?' (knowing question). Finally the child was asked 'When [experimenter 2] comes back in, where will she look for a counter?' (prediction question). Here the child could point to any or all of the three locations. Pointing to the location, and only to that location, where experimenter 2 had seen the counter being hidden was considered correct.

False belief. The positions of the hiding places were rearranged and the brown container replaced by a small toy basket with a small handkerchief to act as a cover. Experimenter 1 produced a pound coin, showed it to the child agreeing with him/her what it should be called, then gave it to experimenter 2 saying 'Now [experimenter 2], will you hide this somewhere?' Experimenter 2 said 'Look I'm going to hide the coin in the basket' and ostentatiously proceeded to do so. Experimenter 2 than left the room again. Experimenter 1 drew the child's attention to the fact that experimenter 2 was no longer in the room and checked that the child recognized that experimenter 2 could not see what was happening. Only then did experimenter 1 ask 'Where did [experimenter 2] hide the coin?' After the correct response, experimenter 1 removed the coin from the basket ensuring the child was attending and hid it in the red purse. The child was then asked a series of questions: (pointing to the new hiding place) 'Does [experimenter 2] know the coin is in here?' (knowing question); 'When [experimenter 2] comes back, where will she look for the coin?' (prediction question); 'Where did [experimenter 2] put the coin in the beginning?' (control question 1); 'Where is the coin now really?' (control question 2). Both had to be answered correctly. Finally the child was asked, 'Where does [experimenter 2] think the coin is?' (think question).

Only on a very few occasions were control questions answered incorrectly. We attributed this to attention lapse, and repeated the test. In each of these rare cases, a correct response was obtained at the second attempt.

Results

Our criterion for passing the line of sight test was at least seven out of eight trials correct. All 15 autistic subjects that we tested on this task passed. On the memory task we tested 14 children all of whom responded correctly to each of two questions.

It seemed to us that these tests were so easy for our autistic sample that we discontinued administering them. The total accuracy validates the use of similar questions as controls in the subsequent tests.

Table 2 shows the number of children passing and failing the limited knowledge and false belief tests. On the knowledge task our criterion of success was a correct response to both the knowing question and the prediction question. On this basis 8 autistic children passed and 10 failed by getting either or both questions wrong. The knowing question was passed by 11 and failed by 7 children. The prediction question was passed by 9 and failed by 9 children. It should be borne in mind that a correct answer could be given to the knowing question half the time by chance. As regards the prediction question, some children failed by pointing to the wrong location, some by pointing to both the wrong and the right location, and some by pointing to the third irrelevant location. To minimize passing by chance, we adopted the stricter criterion of correct response to both knowing and prediction questions.

Table 2. Number of subjects passing and failing the knowing and believing tasks

	Limited knowledge	False belief	
	(strict criterion)	Prediction	Thinking
Autistic			
Pass	8	5	5
Fail	10	13	13
SLI			
Pass	—	12	11
Fail	—	0	1
		$P<0.001$ (Fisher's exact)	$P<0.001$

In addition to the above, we retested a randomly selected subgroup of eight of the autistic children on the same task two months later. All but one of the children performed on retest consistently with their passing (3) or failing (4) on the original test. The inconsistent child passed on prediction both times but failed on the knowing question the first time and passed it the second time.

On the false belief task, five of the autistic children passed and 13 failed the prediction question. On retest all eight children were consistent in passing (2) or failing (6). Passing or failing on the thinking question was completely consistent with passing or failing the prediction question.

The 12 SLI control children without exception passed the prediction and knowing questions on the belief task, while one of the children failed the thinking question.

Autistic and SLI performance on these two questions is significantly different (Fisher exact probability, $P < 0.001$).

There is a high contingency between performance on the limited knowledge and false belief tests in the autistic children, as shown in Table 3. If children fail on the limited knowledge task they also fail on false belief. Performance on these two tasks was not significantly different. Yet there appears to be some degree of independence. Of particular interest are the four children who passed the limited knowledge task but failed the false belief task. These children also passed the knowing question in the belief task. That is, just before saying (wrongly) that experimenter 2 would look for the coin in its new location, these children correctly said that experimenter 2 did not know it was there. On the other hand, one child showed a different pattern of performance and failed only on the limited knowledge task.

Table 3. Relationship between performance on knowing and believing tasks for autistic children (number of subjects passing and failing on both tasks)

	False belief	
	Pass	Fail
Limited knowledge		
Pass	4	4
Fail	1	9

Note. McNemar test for changes, chi-square = 1.23, n.s.

We also looked at the relationship between task performance and the background variables of MA and chronological age (CA). The results are shown in Table 4. It can be seen that there was no relationship between failing/passing and MA. There was, however, a trend which almost reached significance for older children to perform better than younger children.

Table 4. Relationship of performance to background variables in autistic children (mean MA and CA, SD in parentheses)

Limited knowledge[a]				False belief[b]			
Pass ($n = 8$)		Fail ($n = 10$)		Pass ($n = 5$)		Fail ($n = 13$)	
MA	CA	MA	CA	MA	CA	MA	CA
7.4	15.2	7.0	12.7	7.9	15.7	6.9	13.1
(2.8)	(2.5)	(2.2)	(3.6)	(2.8)	(1.8)	(2.1)	(3.5)

[a] Differences for MA, n.s. Differences for CA, $t = 1.66$, d.f. = 16, $P = 0.058$, one-tailed.
[b] Differences for MA, n.s. Differences for CA, $t = 1.56$, d.f. = 16, $P = 0.07$, one-tailed.

Discussion

This present study firmly establishes the fact that autistic children, as a group, have inordinate difficulty with the idea of mental states. The tasks that we used incorporated a number of important methodological refinements compared to our previous studies. We included only autistic children with MA above 4 years, and we compared them with children whose particular difficulty was language comprehension. We performed scenarios using real people rather than dolls and took great care to ensure that the child understood and recalled that experimenter 2 was out of the room when experimenter 1 'conspiratorially' transferred the critical object. The child had to agree that experimenter 2 could not see what was going on. Furthermore we tested the child's understanding of the concept seeing/not seeing independently and were able to demonstrate that every child tested did understand this concept. We also paid attention to possible memory failure for location and found no problem in this respect. In the false belief task, we not only asked each child where experimenter 2 would look for the hidden object but also where she would *think* the object was. In each case, apart from one SLI child, these two questions were answered in the same way. We repeated the tests on a number of children two months later and obtained very consistent results. Given all these safeguards the failure on the mental state concepts of knowing and believing is all the more striking.

The performance of the autistic children was in glaring contrast to that of the SLI children who were of very similar verbal MA. These language handicapped children followed our scenario with enthusiasm and entered into the spirit of the belief task as an opportunity to play a prank on experimenter 2. We did not find this type of enthusiastic collusion in the autistic children. So encouraged were we by the 'normal' response from the SLI children that we tested them on a higher-order false belief task. Such a task tests the ability to handle false beliefs about false beliefs: for instance, Mary may wrongly believe that John wrongly believes that an object is in a certain location. Perner & Wimmer (1985) showed that most 9-year-olds can deal with this concept. Using their task, we found that five out of 10 SLI children, who were all between 8 and 9 years old (verbal MA = 7:1), succeeded in this task. Baron-Cohen (submitted for publication) has recently found that not a single one out of 10 specially selected autistic children who were able to pass the basic false belief task with MAs comparable to our present group could pass the higher-order belief test. By contrast, six out of 10 Down's syndrome children with lower MAs passed this test.

The contrast in performance between our autistic and SLI children suggests that we cannot blame language problems for the specific impairment of mental state concepts in autistic children. This is reinforced by the finding that proper comprehension of the lexical items 'know' and 'think' tends to go together with correct prediction of behaviour. Clearly, we must look for cognitive factors to explain the poor understanding of mental state words and expressions.

Our results confirmed our prediction that the concept of seeing/not seeing would be perfectly understood by our able autistic children regardless of their ability to use mental state concepts. We presume that they employed a geometric concept regarding the causal connection between line of sight and target.

We hypothesized that both the limited knowledge and false belief tasks would require meta-representational skill and that both would be problematic for autistic children. This was the case. As the literature for normal children suggests, the concept of knowing turned out to be slightly, but not significantly, easier than believing. On the limited knowledge task 8 out of 18 autistic children showed understanding of what it means to know that something is the case and not to know this. Four of these children, however, only a few seconds later, failed to understand the consequences when knowledge is false. This interesting subgroup clearly calls for further investigation.

It is plain that the performance on both mental state tasks in our autistic group was extremely poor overall. Given an average MA of over 7 years, it should have been 100 per cent, but it was only 36 per cent taking both tasks together. There is no reason to suppose that performance would improve with higher ability, since being able to take account of either mental state concept was not related to MA. There was, however, a trend for those who did show evidence of meta-representational understanding to be older than those who did not. Perhaps through practice or maturation the autistic child can to some extent increase whatever facility he or she has with mental state concepts. It is conceivable that correct performance in older children is based on compensatory strategies, developed perhaps through years of special schooling. One possibility, at least for the limited knowledge task, is the use of a geometric–causal notion of knowing by analogy with seeing.

We would make the prediction that those children who can pass the limited knowledge and basic belief tasks would show social impairments of a milder variety than those who cannot. We would, for example, expect them to be able to understand if someone pretended, but neither doublebluff nor the difference between lying and sarcasm. These hypotheses are amenable to empirical test.

Very similar results based on different paradigms were obtained by Perner, Frith, Leslie & Leekam (submitted for publication). This convergence of results from an increasing number of studies encourages us further to believe that, in the search for the basic cognitive deficit in autism, we have targeted the right area. The majority of autistic children in the normal range of intellectual ability fail even basic tests of mental concepts, while no autistic subject has yet passed a higher order test. All this supports our claim that autistic children are specifically impaired in their meta-representational capacity, in a way which produces a gross delay in the development of a theory of mind.

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