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What's Inside Someone's Head? Conceiving of the Mind as a Camera Helps Children with Autism Acquire an Alternative to a Theory of Mind

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A group of children with autism were taught a specific strategy to help them solve a series of theory of mind problems. We focused our teaching on the false-belief task and taught them the analogy that people have photos in their heads. This strategy draws on a domain of intact cognition in autism (understanding *photographic* representations) to bypass a cognitive impairment in a certain domain (understanding *mental state* representations). All the children were able to understand photographic misrepresentation during teaching and, following specific teaching, they could use the strategy of visualising photos in characters' heads to predict the character's behaviour. In contrast, none of the children could use the photo strategy to predict a character's mental states. The educational and theoretical implications of this study are discussed.

INTRODUCTION

A central cognitive deficit in people with autism is their impairment in employing a theory of mind (Baron-Cohen, Leslie, & Frith, 1985; Baron-Cohen, Tager-Flusberg, & Cohen, 1993; Frith, 1989). They have difficulties in understanding mental state concepts and in using such concepts for predicting

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behaviour and in communicating with others. For example, they are unable to understand that when a person holds a false belief, they will act on the basis of this misrepresentation rather than on the basis of reality. This deficit has been attributed to the impairment of a cognitive mechanism (ToMM, or Theory of Mind Mechanism) dedicated to processing the kinds of representations needed for mental state comprehension. Leslie (in press) proposes that understanding mental states requires the ability to form a special class of representations (called M-Representations) of the form {Agent–Attitude–''Proposition''}.

The theory of mind deficit in autism has been repeatedly demonstrated by a variety of research and has given rise to important theoretical debates as to its nature (see, for example, Baron-Cohen et al., 1993; Happé, 1994a). However, less attention has been devoted to the issue of whether it would be possible to *compensate* for this deficit. The aim of the present study was to explore a possible way of helping people with autism to *bypass* their deficit in understanding and employing mental state concepts.

Previous attempts at training a theory of mind in autism have focused on providing examples of theory of mind problems and giving feedback as to the appropriate response, in the hope that children with autism will learn the necessary mental state concepts. Swettenham (1996) used a computer-animated version of the Sally-Anne false-belief task with autistic, Down's syndrome, and young 3-year-old children. A variety of distant transfer tasks were used to assess what had been learned during teaching. Although the children with autism were able to pass the computerised task, and could generalise to the same scenario using dolls, they were not able to generalise what they had learned to other related false-belief tasks using different scenarios. In this study, the mean Verbal Mental Age (VMA) of the autism group was 3 years, 8 months (matching a young normal control group) and a mean Chronological Age (CA) of 10 years, 9 months, well above the normal CA (approximately 4 years old) for passing such tasks. Hadwin, Baron-Cohen, Howlin, and Hill (in press) carried out a larger-scale training study that included a subgroup of children with autism who were taught about the mental state of false belief. The mean VMA of the group was 5 years, 2 months and mean CA was 9 years, 2 months. Conventional materials were used (e.g. dolls, Smarties packets) and feedback given. Only *limited* transfer was established, in that children only learned to pass the particular scenario used during training, but involving different materials. More distant transfer tasks using different scenarios were not employed in this study. Similar results were found by Bowler, Stromm, & Urquhart (1993) (mean CA = 10 years, 6 months; mean VMA = 6 years, 7 months) and Whiten, Irving, & Macintyre (1993) (mean CA = 24 years, 7 months; mean VMA = 5 years, 4 months). In both these studies repeated examples of the Sally-Anne false-belief task were shown, the former using dolls and the latter using real people. Children with autism *did* learn to pass the training task, and transfer their knowledge to pass the *same* task using *different*

materials. However, transfer tasks with different scenarios were not used in these studies.

It is not clear, then, whether these tasks were providing an adequate alternative route for dealing with theory of mind problems. Swettenham (1996) suggests that children with autism simply learn a strategy to pass these tasks. In addition, in these attempts, children were left to develop spontaneously any strategy on their own, to solve the tasks. These strategies varied in their usefulness. Our aim in the present study was explicitly to teach children with autism to employ a *specific* compensatory strategy, which we predicted would be very useful, as it was based on one aspect of their intact abilities.

Conceiving of Beliefs as Photos

Zaitchik (1990) devised an ingenious test to compare young normal children's understanding of mental representations, such as false beliefs, with that of nonmental representations, such as false photographs. In her task, the subject took a Polaroid photo of an object in location X, and while the Polaroid photo was developing, and before the image was visible to the subject, the object was then moved to location Y. Subjects were asked ''In the picture, where is the object?'' Zaitchik's task is elegant in mirroring the demands and design of the standard false-belief task, but in substituting a nonmental representation (a photo) in place of the mental one (a belief). Zaitchik found that 3- to 4-year-olds had equal difficulty reasoning about photographs as they did about beliefs.

Leslie and Thaiss (1992) and Leekam and Perner (1991) found that, although most children with autism were unable to understand that a person's belief can differ from reality, most could understand that a photograph can differ from reality. That is, they were able to understand that an object's location would remain the same in a photograph, even when this had changed in reality. Charman and Baron-Cohen (1995) also demonstrated this effect using ''false'' drawings and models. This suggests that, whereas children with autism have severe difficulty in understanding *mental states* as representations, they are able to understand *physical states* as representations.

We reasoned that their intact ability in understanding physical representations might provide a valuable basis for allowing children with autism to develop an alternative strategy to make sense of and predict behaviour. Specifically, we attempted to teach children the strategy that *the eye is like a camera* and that *people have pictures in their heads*—that is, the idea that mental state representations are just like photographic representations. Of course, mental states are not ''just like'' photos in all sorts of respects. For example, mental states are unobservable, they are only held by animate agents (as far as we know), and they may not be visually image-based. As Leslie and Thaiss (1992) suggest, the fact that normal children do not find false photos any easier than

false beliefs (and may even find beliefs *easier* than photos) makes it highly unlikely that normal children use a photo-in-the-head model of mental states. And whereas for us as adults, photos serve only as a reasonable *metaphor* for what beliefs are like (they are *about* other things, they *endure* even when reality changes, they can be accurate or inaccurate in their informational relation to the things they are about, etc.), for children with autism, they may be the closest approximation to what beliefs are *actually* like, if they cannot conceive of beliefs themselves. We therefore set out to teach children with autism that beliefs were ''just like'' photos, and we left it open as to whether they took this as a metaphor (as we would) or as being a literal statement of fact. Whichever way they took it, might it help?

Preliminary evidence suggests that some people with Asperger syndrome *already* use pictures to help them come to some understanding of mental representations. Hulbert, Happé, and Frith (1994) studied the self-reports of inner experience in three people with Asperger syndrome and found that they described their mental contents entirely in terms of pictures in the head. This was in contrast to normal controls, who described a mixture of inner speech, pictures, and ''pure thought'' (Hulbert, 1990). Furthermore, in this small group of people with Asperger syndrome, ability to report inner experiences in terms of pictures was closely related to ability to pass false-belief tasks, independent of IQ (Happé, 1994a).

It is important to emphasise that we think of this method as a prosthetic device to compensate for the lack of a real mechanism (much as Braille is used to enable a blind person to read; see Baron-Cohen & Howlin, 1993). That is, we were under no illusion that this method would result in a normal theory of mind being acquired by children with autism; for example, this alternative would clearly be a *consciously constructed theory*, whereas a ''real'' theory of mind has been argued to be an *implicit and unconscious mechanism*[1] (Leslie & Thaiss, 1992; Frith, Morton, & Leslie, 1991). However, our method might provide a usable alternative theory (a theory of the mind-as-a-camera) with which to explain and predict a person's actions.

Like most other previous studies, we focused on teaching the ability to understand false beliefs. Our prediction was that using the photo-in-the-head method the children would not just learn to solve a specific task, but would develop a powerful, generalisable strategy that would enable them to deal with a variety of problems involving mental states. More specifically, we predicted that this strategy would be useful for a range of theory of mind transfer tasks, but would have clear limitations for others. Explicit teaching of the photo strategy, involving a number of different steps, was given to the children only in a version

[1]Other theorists have argued that theory of mind may be a consciously constructed theory. The point here was merely to highlight what *may* be a crucial difference between our strategy and a normal theory of mind.

of the classical Sally-Anne false-belief task (Baron-Cohen et al., 1985). However, four different types of *transfer tests* were given before and after teaching, in order to assess whether the children were able to generalise the strategy. These four tests were: (1) a different version of the Sally-Anne task; (2) a deceptive contents task (''Smarties task''); (3) a ''seeing-leads-to-knowing'' task; and (4) an appearance–reality task. (A description and references are given later.) Our prediction was that the photo strategy would be useful in generalising to the first three tasks only, because they all involved scenarios where the contents of the photograph would differ from reality. In contrast, we assumed that the last task (appearance–reality) could not be solved using the ''photo-in-the-head'' strategy, because the information in the photograph would look exactly the same, irrespective of whether the object's apparent or real identity was being portrayed.

METHOD

Subjects

The subjects were eight children with autism, all of whom had been diagnosed according to established criteria (DSM-IIIR, 1987; Rutter, 1978). Verbal mental age (VMA) was assessed using the Test of Receptive of Grammar (TROG; Bishop, 1983). Table 1 shows the subject details for this study. The eight children had been selected from an initial sample of 12 on the grounds that they failed the Sally-Anne false-belief task (Baron-Cohen et al., 1985) and the ''Smarties'' false-belief task (Perner, Frith, Leslie, & Leekam, 1989), as it made no sense to include those who were passing in a training study of this kind. Two versions of each inclusion task were used and subjects were required to pass all the control questions. The decision to limit the sample size to $n=8$ was made because of practical constraints, given the intensive nature of the study (approximately one hour per day of teaching per child, over five consecutive days). The sample size was, however, taken into account in the statistical analysis.

TABLE 1
Subject Variables: Means Standard Deviations, and Ranges of Chronological Age (CA) and Verbal Mental Age (VMA)

	CA (Years:Months)	*VMA (Years:Months)*
Mean	11:6	6:0
SD	(2:1)	(1:1)
Ranges	8:9–14.4	5:0–6:0

Design

Teaching took place over five days in a quiet room within the school, with one session per day lasting approximately 40–60 minutes. Each child was taught a number of rules. These could be divided into four stages of teaching:

1. Assessing *basic rules* for the photo analogy (9 steps).
2. Assessing *spontaneous use of the basic rules* for solving the false-belief task.
3. Teaching explicit rules linking the *photo to mental states* (3 steps).
4. Teaching explicit rules linking the *photo to actions* (2 steps).

Each of these stages consisted of a series of steps which involved a demonstration and questions to check that the child had understood the principle involved. A child was considered to have passed (or understood) a step when he or she answered correctly on three successive trials out of a maximum of six presentations. Finally, four transfer tasks were given before and after the block of teaching. These were presented in counterbalanced order within the group.

Materials

A large, life-size manikin's head (commercially available) was adapted for teaching. A slot cut in the top of the head enabled a photo to be inserted so that the picture was literally inside the manikin's head and out of sight from the child. Photographs of objects and events used throughout teaching were prepared beforehand, using a Polaroid camera. The objects used were a slipper, a ball, a hand puppet, a bat, a toy dinosaur, and a pink bottle.

Procedure

Transfer Tasks

As mentioned earlier, four transfer tasks were administered before and after the five-day block of teaching. Previous studies report that all of these tasks are failed by the majority of children with autism, whereas normal 3- to 4-year-olds generally pass these tasks. These comprised:

(i) The Sally-Anne False-belief Task (S-A). In this task, character A places an object in location X. In A's absence, character B moves the object to a new location, Y. When A returns, the child is asked ''Where will A look for her ball?'' To pass this test the child has to understand that A will have a false belief about the true location of the object and so search in the wrong location. This scenario was the same as that being taught. The procedure for this task was modelled closely on that described in Baron-Cohen et al. (1985), which the reader should consult for details, including control questions. Three trials were

presented with the correct answer being a different location each time. Although this task is close in structure to the scenario used during teaching, no reference to photos-in-the-head is made. Because of this important difference this task is included as a *transfer task*.

(ii) The Smarties Task (SM). This task was based on the false-belief paradigm used by Perner, Leekam, and Wimmer (1987) and Perner et al. (1989). The child is presented with a Smarties packet (a well-known British confectionery; M&Ms in the United States) and is asked what is inside. When the child responds that the packet contains Smarties (a correct assumption) the experimenter shows the child that, in fact, the packet contains a pencil. The child is then asked about his or her own belief (''Before we opened it, what did you think was in here?'') and about another person's false belief (''If we show this to X, what will X think is in there?''). The reader should refer to Perner et al. (1987) for further details. Two trials were presented at pre-test and two at post-test; each involved different materials.

(iii) The Appearance–Reality Task (A–R). In this task, the subject is shown an object which appears to be one thing (e.g. an egg). The subject is then encouraged to explore the object to discover that the object is really something else (e.g. a stone). The child has to understand that an object looks like an X but is really a Y. This is one way of examining the child's ability to attribute mental states to himself or herself (Flavell, Green, & Flavell, 1986). The *material*, *identity*, and *colour* versions of this task were used; one example of each at pre-test and a different example of each at post-test. In the *material* version we used a plastic, realistic-looking chocolate, and a plastic realistic-looking hamburger; the *identity* version involved a stone, a realistic-looking egg, a sponge, and a realistic-looking slice of bread; and in the *colour* version a white milk bottle and some white chalk were covered by an orange filter. The test questions were ''What does it look like?'' and ''What is it really?'' The child's task being to distinguish between the appearance of the object and its real identity. The procedure for this task was modelled closely on that described by Baron-Cohen (1989), which the reader should consult for further details. Subjects were required to pass all three versions in order to pass the task as a whole.

(iv) The Seeing-Leads-to-Knowing Task (S–K) In this task, the child is shown two doll characters, one of whom *looks* into a box and one of whom simply touches the box while the box's lid remains closed. The child is then asked ''Which one *knows* what is in the box?'' The procedure for this task was modelled closely on that described by Baron-Cohen and Goodhart (1994). There were three trials at pre-test and three at post-test. The character who looked was varied randomly across the trials.

Teaching Sessions

Stage 1: Basic Rules for the Photo Analogy

Step i. The experimenter (E) introduces the Polaroid camera by taking several photos of familiar objects. The child and E then watch the photos develop. E then looks at some objects, exaggerating this by opening her eyes wide and blinking, and explains to the child that when she looks at something and blinks she gets a photo in her head. The child is then asked to watch the experimenter's eyes carefully and say when the experimenter gets a photo in her head. The experimenter than looks randomly at different objects around the room, in an exaggerated way, and blinking at each new object she looks at, to draw attention to her eyes. The aim of this step is to remind the child about photographs in a camera, and to introduce the metaphor that when a person looks at something he or she will get a photograph in her head.

Step ii. Five objects are placed in a row (ball, car, cup, bag, and box). Sally (the manikin's head) faces one of these objects. Sally is then made to face each of these five objects in turn. The child is asked ''Which object is Sally looking at?'' Correctly answering this question for the five objects is considered the starting point for training. This step tests if the child can identify what Sally is *looking* at.

Step iii. The child is reminded that ''When a person looks at something, they see it, and this means that they make a sort of picture in their head''. A demonstration is made by inserting the appropriate photograph into the manikin's head, as it faces a different toy, one at a time. Each time the head faces a new toy, the previous photo in the head is replaced by the new, appropriate photo. This step is a concrete *demonstration* that seeing an object X leads to a photograph of X in Sally's head.

Step iv. Sally then looks at each of the objects and the child is asked ''Which picture has Sally got in her head?'' The child's task is to choose the right photograph from an array depicting each of the objects. The aim of this step is to *test* if the child understands that seeing object X leads to a photograph of X in Sally's head.

Step v. This step is the same as step iv; however, the child is required to insert the correct photograph into the slot in Sally's head. This step reinforces step iv with the *action* of placing the photograph in Sally's head.

Step vi. Sally looks at an object and the appropriate photo is slotted into her head. Sally then leaves the scene where the object is, and Sally is put in a new location, out of sight of the child. The child is then asked ''Which photo has Sally got in her head?'' The child's task is to identify verbally the contents of the photograph. Following this, the photograph is taken out of Sally's head and shown to the child. The aim of this step is to test if the child can verbally identify the contents of the photograph, and understand that the photograph of the object remains in Sally's head even when she is out of sight of the object.

Step vii. Sally looks at an object and again the photo of the object is slotted into Sally's head. As before, Sally then leaves the scene. The object that she looked at is then put away, so that it is no longer in view. The child is asked ''Which photo does Sally have in her head?'' The child is required to answer this question without looking at the photo. Following this, the photograph is taken out and shown to the child. The aim of this step is to test if the child can identify the contents of the photograph in Sally's head, when a matching strategy with a visible object is not available.

Step viii. The child is told ''Keeping a photo in your head is useful because when you *want to find* something, you just *look at the photo* in your head''. A demonstration is then given to the child:

Sally places object X in location A.
Sally takes a photo of ''X in A'' (this photo is inserted into Sally's head).
Sally leaves, the photo of ''X in A'' stays in her head.
Sally returns and says ''I want to find X''.
Sally looks at the photo in her head, and says ''Ah! X is in A!''
Sally then goes to A.

This is repeated up to the penultimate line. The child is then asked ''In Sally's photo, where is X?'' If the child answers correctly, the experimenter carries on to demonstrate that Sally looks for X in A. If the child is wrong, the experimenter takes the photo from Sally's head and demonstrates that X was in A in the photo. The aim of this step is to demonstrate that Sally will refer to the photograph in her head when deciding where to look for an object, and will act according to the contents of the photograph.

Step iv. The child is told ''If something moves or changes, and you don't see it move, then the photo in your head stays the same''. This step involves a second doll character called ''Anne''. The following demonstration is given to the child:

Sally places an object X in a location A.
Sally takes a photo of ''X in A'' (the photo is inserted into Sally's head).
Sally leaves, while the photo of ''X in A'' stays in her head.
Anne enters and moves X from A to a different location B.
The child is then asked three questions:
''Can Sally see what is happening?'' (Correct answer = No).
''Can Sally make a photo of X in B?'' (Correct answer = No).
''What photo will Sally have in her head?'' (Correct answer = X in A).

If the child is unable to answer the questions correctly, the correct answer and an explanation are given. The experimenter then demonstrates that Sally looks for ''X in A''. The aim of this step is to test the child's understanding that the content of the photograph in Sally's head (e.g. object X in location a) does not change if Sally does not see a change in the world (e.g. object X being moved to location B).

Stage 2. Assessing Spontaneous Use of Basic Rules for Solving the False-belief Task. This stage is the same as Stage 1, step ix, but instead of demonstrating Sally's thoughts and actions the experimenter asks the child to infer and predict the following:

''Where does Sally think X is?''
''Where will Sally look for X?''

The experimenter records if the child now spontaneously passes these questions.

Stage 3. Explicit Rules Linking the Photo to a Mental State. In this stage, the child is taught to use the contents of the photograph to infer Sally's belief.

Step i. The first step in Stage 3 collapses Stage 1, steps i–iv. The experimenter shows Sally looking at one of five objects; the child then chooses which photo should go in Sally's head. The photo is inserted into Sally's head, and the child is then asked to name the contents of the photo once more. The aim of this step is to check that the child had retained the basic rules of the photograph analogy learned in Stage 1.

Step ii. The object remains on the table in front of Sally. Then the child is told that what is in the photo is the same as what Sally *thinks* is on the table. The experimenter then asks the child two questions:

''What is in the photo?''
''What does Sally think is on the table?''

If the child answers wrongly, the correct answer is given with an explanation that what is in the photo is what Sally thinks. The aim of this step is to test whether the child understands that the contents of the photograph in Sally's head indicate what Sally is *thinking.*

Step iii. Following step ii, a screen is placed between Sally and the object. The child is then asked if Sally can see the object. Then the object is replaced by a new object, and the child is asked two questions:

''What is in the photo?''
''What does Sally think is on the table?''

Once again, if the child answers incorrectly, the correct answer is given with an explanation that what is in the photo is what Sally thinks. The aim of this step is to test if the child can identify the contents of the photograph in Sally's head and use this to infer his or her belief, when a matching strategy with a visible object is not available.

Stage 4. Teaching Explicit Rules Linking the Photo to Action. In this stage, there is no reference to what Sally is thinking. The child is taught to predict action using the photograph in Sally's head. The following demonstrations are given to the child:

Sally places object X in location A.
Sally ''takes a photo'' of ''X in A'' (the photo is inserted into Sally's head).
Sally leaves, keeping the photo of ''X in A'' in her head.
Anne enters and moves X from A to a different location, B.

The child is asked:

''What photo does Sally have in her head?''

If the child answers correctly, the child is then told:

''If Sally wants to find X, she will go to the place in the photo where X is.''

The child is then asked:

''Where will Sally look for X?''

This is repeated with feedback.

Results

Performance during Teaching

Table 2 shows the number of children who passed[2] each of the rules during the teaching sessions. All eight children passed the basic rules of the photo analogy. In fact, three successive correct trials were given within four trials on each of the steps in Stage 1. Stage 2 (spontaneous use of photos for the false-belief task) and Stage 3 (explicit rules linking the photo to mental states) were both failed by all eight children. However, Stage 4 (explicit rules linking the photo to actions) was passed by seven out of eight children (88%), and for each of these passing subjects the three correct criteria was achieved within the first four trials (five subjects achieving this on the first three trials).

TABLE 2
Performance During Teaching: Number of Children out of 8 Passing Photo Strategy Teaching Stages

Stages	*No. Children Passing*
1	8
2	0
3	0
4	7

[2]Passing a rule was defined as three successive correct trials on each step.

TABLE 3
Pre-test and Post-test Transfer Tasks: Results and Analysis

Task	*Pre-test (No. Passing)*	*Post-test (No. Passing)*	*Wilcoxon*	
			z	*P*
Sally-Anne	0	7	2.37	0.18
Smarties	0	3	1.34	0.179
Seeing–Knowing	0	6	2.20	0.028
Appearance–Reality	3	3	0	1.000

Transfer Task Performance Before (Pre-test) and After (Post-test) Teaching. The results and analysis for the pre- and post-test transfer tasks are shown in Table 3. This shows the number of children passing each of the four transfer tasks before and after the block of teaching. As with the pre-test, subjects had to be correct on all three presentations of a task before they were counted as ''passing''. The change in performance for the group was analysed using Wilcoxon's nonparametric test. A significant improvement in performance was found in two of the transfer tasks: (1) the Sally-Anne task ($P < 0.05$), where the number passing increased from 0 to 9 following teaching; and (2) the seeing leads to knowing task ($P < 0.05$), where the number passing increased from 0 to 6. There was also a slight improvement in performance on the Smarties task, from 0 to 3 children passing, although this difference was not significant at the 5% level. In contrast, there was no change in performance on the appearance–reality task.

DISCUSSION

In this study, we set out to teach a small group of children with autism a specific strategy to help them solve theory of mind problems. This strategy was based on the analogy between photographic representations (which children with autism seem to understand) and mental representations (which they have particular difficulty understanding). All the children were able to learn the basic steps of the photo strategy. They could identify the contents of the photo on the basis of what a person was looking at, and understand that the contents of the photo do not change if the person cannot see the world change, confirming previous findings that children with autism can understand photographic misrepresentation (Leekam & Perner, 1991; Leslie & Thaiss, 1992). The strategy was not spontaneously used to predict behaviour or mental states. However, when the children were explicitly taught the link between photos and action, all of the children were able to make *behaviour predictions.* In contrast, none of the children were able to use photos as a basis to infer *mental states*, despite explicit teaching.

We assessed the effectiveness of teaching the strategy by using transfer tasks. We predicted that the strategy would be generalised to three out of the four transfer tasks. This prediction was confirmed for the Sally-Anne false-belief task and the seeing-leads-to-knowing task, where significant improvement took place. There was also a trend reflecting improvement in the Smarties task. It was also confirmed that the strategy was not useful in helping children solve the appearance–reality tasks. This discrepancy is consistent with the notion that the improvement in performance was specifically due to use of the photo strategy. As previous training studies have failed to find evidence of generalisation when teaching theory of mind concepts, the generalisation we found in this study therefore suggests that the strategy is a useful one and worth pursuing in other studies.

The data also raise a number of interesting issues. First, why was it more difficult for the children with autism to use photos to infer mental states than to predict behaviour? One possibility is that because children with autism have a specific difficulty in representing the mind, they are only able to make the link between photo and action. That is, they cannot carry out the intermediary stage of substituting a photo for a mental state. This is represented in Fig. 1.

Children with autism seem only able to make the direct inference from photo to behaviour represented by the solid line. They do not spontaneously make the inference from photographic representation to mental state representation (the broken line in Fig. 1). Nor do they appear to learn this route.

Having set up this model in Fig. 1, we now wish to show how the two routes are not mutually exclusive. As the children with autism did learn to pass the seeing-leads-to-knowing task, this shows that they were not *restricted* to the behavioural prediction route alone. They must have developed some notion of the mental state of *knowing*. However, given that they could not answer the *think* question on the Sally-Anne task, this implies that they had only a very partial grasp of the mental state route in the model.

Next, we turn to the possible advantages and disadvantages of teaching the theory of mind-as-a-camera to children with autism. On the one hand, it might be thought that providing such an unnatural strategy might lead to greater confusion, and may even be ethically unjustifiable. We are sensitive to these objections but have concluded that, on balance, the advantages of having *some*

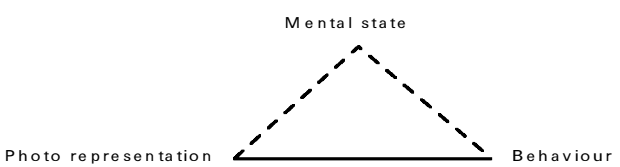

FIG. 1. Normal and abnormal strategies for predicting behaviour, in the training method (—, abnormal; - - -, normal).

strategy outweigh the potential disadvantages. The clearest test of the value of such training will be in the use people with autism make of it. If such training approaches lead them to have better access to the social world, and to feel less excluded, then this is justification enough for developing such approaches. Until similar programmes are implemented on a broader and deeper level, however, this issue remains unresolved.

We should emphasise that this specific intervention approach has *not* attempted to retrace the point in development where the deficit in autism first occurred, and then attempted to treat that. Rather, and as stated earlier, it has attempted to provide a prosthesis, intentionally artificial. Whether a developmental approach to intervention would be of greater value is an issue that should be explored. For example, if joint attention is a critical precursor for the development of a theory of mind in the normal case (Baron-Cohen & Swettenham, 1996), and given that joint attention is absent or impaired in autism, should treatment focus on training joint attention in toddlers with autism? As a result of improved methods for early detection of autism at 18 months (Baron-Cohen, Allen, & Gillberg, 1992; Baron-Cohen et al., 1996), this idea becomes a feasible proposal.

In closing, we consider possible applications and extensions of this work. It seems likely that the basic idea of making mental states *concrete* by analogy with *photos* could also be achieved with other media, such as drawings, and even more conventionally, cartoon think-bubbles. We have recently tried this in a single case study of a person with autism, with the finding that the think-bubble analogy led to her passing theory of mind tasks (Gomez, personal communication). There is also good evidence that young normal 4-year-olds find think-bubbles very easy to interpret as mental states (Wellman, Hollander, & Schult, 1995). From the current study we suggest that both the photo and related methods may be powerful tools for bypassing the theory of mind deficit in autism. It remains to be seen whether, if such teaching methods were incorporated into special education curricula all year round, one would see changes in core symptoms related to theory of mind, such as social abnormalities and pragmatics (Baron-Cohen, 1988; Tager-Flusberg, 1993).

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