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Understanding Photos, Models, and Beliefs: A Test of the Modularity Thesis of Theory of Mind

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Recent experimental findings suggest that there is a dissociation between the performance by children with autism on False Belief tasks, on which they do poorly, and False Photograph, False Maps, and False Drawing tasks, on which they do well. This may be because only the False Belief task taps the capacity for metarepresentation, at least as defined by Leslie and Thaiss (1992). In an attempt to test the modularity of this capacity further, the performance of participants with autism on DeLoache's (1987, 1991) Model and Photograph tasks (which test understanding of the symbolic function of models and photographs), and on a standard False Belief task, was compared to that of mental handicap controls. The majority of participants from both groups passed the Photograph and Model tasks, and on neither task were there group differences. However, participants with mental handicap were significantly more successful on the False Belief task than those with autism. These results provide further support for the modularity of theory of mind, and the specificity of the metarepresentational deficit in autism.

Recent work has demonstrated a dissociation in the performance of children with autism on False Belief tasks, on which they do poorly (see Baron-Cohen, 1993; Happe, 1994, for reviews), as compared with tasks which assess their understanding of False Photographs (Leekam & Perner, 1991), False Maps (Leslie & Thaiss, 1992) and False Drawings (Charman & Baron-Cohen,

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1992), on which they do well. False Belief tasks test the participant's ability to understand that an agent may hold outmoded (and therefore false) beliefs about a state of the world which has changed without their knowledge (Wimmer & Perner, 1983). In contrast, False Photograph, False Drawing, and False Map tasks test the participant's ability to understand that physical representations may be outmoded (and therefore false) when the state of the world has changed (Zaitchik, 1990).

Leslie and Thaiss (1992) argue that the dissociation in performance between the two types of tasks in autism provides evidence for *domain specificity* in the development of representational systems. In their view, False Belief tasks, but not False Photograph or False Map tasks, require a Theory of Mind Mechanism (ToMM). Only the latter makes explicit the informational relation, or attitude, that an agent bears to a proposition, that is, representing that agents have *mental* representations. It is this ability which they argue is lacking in children with autism, causing them to fail the False Belief task, although passing the False Photograph and False Map tasks (which can be passed using an understanding of *nonmental* representations). Charman and Baron-Cohen (1992) provide a similar explanation for the differential performance of participants with autism on False Belief and False Drawing tasks.

In order to investigate the modularity thesis further, we tested children with autism using some additional experimental tasks. Specifically, we looked at their understanding of the symbolic properties of models as compared to photographs. Such understanding appears to emerge relatively suddenly in normal development, between the ages of 2.5 and 3 years of age (DeLoache, 1987, 1991). DeLoache's experiments suggest that 2.5-year-old children cannot appreciate the relation between a scale model and its referent, but can do so for a photograph, or a drawing, and its referent. In contrast, 3-year-olds are able to understand this relationship for both photographs *and* models.

To explain this developmental change, DeLoache (1991) posits a "dual orientation" hypothesis. By this she means that toddlers are coming to appreciate that certain things are both objects in their own right and symbols of other things, and that one needs to hold *both* identities in mind simultaneously. She argues that young toddlers may find the relationship between a photograph (or drawing) and its referent easier because they can attend exclusively to its primary function as a representation of something else. In support of this, when she cued the 2.5-year-olds to respond to photographs as objects in their own right (by hiding another object behind them), they were no longer able to respond to them as symbols. DeLoache's idea, then, is that the 2.5-year-old cannot sustain the "dual orientation" simultaneously.

In contrast, DeLoache (1991) suggests that an ability to relate a model and its referent necessarily requires "dual orientation": "One must think about the model in two different ways at the same time—as the object that

it is and as a symbol for something that it is not." (p. 737). Further, DeLoache equates the representational demands of the model task to those of pretence, in which a child must represent a single thing in two different ways—as what they *know* it is and as what they *pretend* it is. Leslie (1987) characterized the dual representation involved in pretence as an early manifestation of the child's ability to metarepresent, and directly linked the cognitive capacities required in pretending to the later development of a theory of mind. Stemming from this framework, one possibility is that ToMM is not modular as Leslie proposes (Leslie & Thaiss, 1992; Leslie & Roth, 1993; Leslie, 1994), but depends on what DeLoache calls a capacity for "dual orientation."

This article reports on a study that investigated the performance of participants with autism, and a group of participants with a mental handicap but without autism, on DeLoache's (1987, 1991). Model and Photograph tasks, and then compares this with their performance on standard False Belief tasks. If ToMM is not modular, but depends on the more general capacity for dual orientation, two predictions follow: (a) participants with autism should pass the DeLoache Photograph task because understanding this may only require understanding the symbol-referent relation, which itself may only involve recognition of a "correspondence" (Lillard, 1993); and (b) Participants with autism should fail both the DeLoache Model task and the False Belief task, since both the DeLoache Model task and the False-Belief task are held to require a capacity for dual orientation. In contrast, the modularity thesis predicts a different pattern of results: Participants with autism should pass both the DeLoache Photograph and Model tasks, as these only involve understanding *non-mental* representations, but uniquely fail the False Belief task, as this alone involves understanding *mental* representations.

THE EXPERIMENT

Participants

We tested 19 participants with autism (16 boys, 3 girls); all of them had been diagnosed according to established criteria (DSM-III-R [1987]; Rutter, 1978), and 19 participants with mental handicap of uncertain aetiology but without autism (9 boys, 10 girls), in order to control for mental age (MA) and chronological age (CA). Details about the participants are summarized in Table 1. Participants were only included in the study if both their VMA (verbal mental age) and NVMA (non-verbal mental age) were above 42 months, the age at which normally developing children reliably pass the DeLoache Model task (DeLoache, 1987, 1991).

Although there were no differences between the groups in terms of VMA, $t = 0.42$, $df = 35$, $p > 0.10$, the participants with a mental handicap had a higher CA, $t = -2.95$, $df = 36$, $p < 0.01$, and the participants with

Table 1. Subject Variables: Means, *SD*'s, and Ranges of Chronological Age (CA) and Mental Age (MA) in Months

Diagnostic Groups	*n*		CA	Verbal MA[a]	Nonverbal MA[b]
Autism	19	*M*	142.7	58.0	95.0
		SD	42.4	12.6	24.8
		Range	78–216	48–96	57–144
Mental Handicap	19	*M*	178.4	56.5	54.7
		SD	31.1	8.6	11.9
		Range	106–229	42–72	42–84

[a]TROG, BPVS. [b]Ravens Matrices.

autism had a higher NVMA, $t = 6.4, df = 23, p < 0.001$. VMA was assessed using the Test of Reception of Grammar (TROG: Bishop, 1983), or the British Picture Vocabulary Scale (BPVS: Dunn, Dunn, Whetton, & Pintillie, 1982) for those participants who fell below the floor of the TROG (48 months). NVMA was assessed using Raven's Colored Progressive Matrices (Raven, 1956). Due to noncompliance, it was not possible to collect NVMA data on three participants with autism.

Materials

A significant adaptation was made to the equipment used by DeLoache (1987, 1991), in order to make the apparatus portable. A similar methodology has previously been employed with normally developing children (Blades & Cooke, 1994; Blades & Spencer, 1994). The real object was a suitcase containing four items of clothing to act as the four hiding places (a shirt, a pair of trousers, a pair of socks, and a pair of shoes). A scale replica model of the suitcase (scale approximately 1:5) was made. This contained replicas of the four items of clothing that were similar in shape, design and color. Individual photographs (10 cm by 10 cm) of the four real items of clothing (on a blank background) were available. In addition, a 10 pence coin was hidden instead of the toy used by DeLoache.

Procedure

The DeLoache Model and Photograph Tasks. Apart from the change of apparatus outlined above, the procedure followed that described in detail by DeLoache (1991). A brief summary will be given here with significant differences between the current procedure and the one that DeLoache's original study highlighted. Each participant was tested in a quiet room in his or her school. The two sets of trials, the four Model trials and the four Photograph trials, counterbalanced for order across participants, were given approximately 30 min apart. The psychometric tests used to collect mental

age data were administered during the gap. After a short warm-up period, during which participants played with a variety of toys, or were asked about what they had been doing at school that day (depending on which was more age-appropriate), participants were oriented to the apparatus. The experimenter explicitly described and demonstrated the correspondence between the individual items of clothing in the suitcase and the model, or the photographs. The participant was asked to look away, and the coin was hidden under one of the four items of clothing in the suitcase (without the subject seeing). The information about the hiding place of the coin was conveyed to the child by the experimenter pointing at the appropriate piece of clothing in the model suitcase, or the appropriate photograph, respectively (equivalent to the DeLoache "point-model" and "point-picture" trials), saying, "The coin is here in the suitcase. The coin is hidden here." The participant was given 30 s to make a response. The model or the photographs were arranged on a separate table adjacent to that on which the suitcase was placed. To move from the pointing event to the retrieval event, the children had to move themselves around in their chair from one table to another. Thus, the distance between the "cue" model or photograph and the "real" location was considerably reduced from that in DeLoache's design where the child was led from one room to another. It was possible for the child to look back-and-forth from the cue (model or photograph) to the suitcase (though no pointing cue was continuously provided). However, most children eagerly commenced their search without further reference to the photograph or model, only returning to the model or photograph after an unsuccessful search, if at all. The first location at which the participant attempted to retrieve the coin was scored as either a successful, or an unsuccessful, retrieval. Following DeLoache, the child was prompted to continue searching in the suitcase if their first search was incorrect, and the trial concluded with the child retrieving the coin. All four locations were used across the four trials, in randomized order.

The False Belief Tasks. In the same session, participants received a False Belief task, similar to that developed by Perner, Leekam and Wimmer (1987). The procedure followed that described by Lewis and Osborne (1990) and Charman and Baron-Cohen (1992). The participant was shown a familiar toothpaste box and was asked "What do you think is inside this?" All the participants said toothpaste. The box was then opened and the participant was shown it really contained money (coins). The box was then closed again, and he or she was then asked "Now what do you think is inside this box?" All of them said "money" or "coins." This confirmed that their belief had now changed. The participant was then asked the Belief Question, "*When* I first asked you, *before* we opened the carton, what did you think was inside?" This was repeated on a subsequent trial, using a Smarties (M&Ms)

tube with a pencil inside. The two False Belief trials were conducted at different points in the session, with a substantial period of time and activity between the two.

RESULTS

The number of participants who were successful in the retrieval of the coin on the four Photograph and four Model trials, and on which they correctly answered the False Belief question in the two False Belief trials, are shown in Table 2. Both the participants with autism (94.7%) and the participants with a mental handicap (96.1%) were near ceiling on the Photograph task, and successfully retrieved the coin on over two thirds of the Model trials (71.1% and 81.6%, respectively). There were no differences between the autism and mental handicap groups on the Photograph and Model tasks (for both Kolmogorov-Smirnov two-sample test, $p > 0.10$). However, on the False Belief task the participants with autism succeeded in only 26.3% of trials, although the mental handicap controls scored significantly better, succeeding twice as often, 52.6%; Kolmogorov-Smirnov, $p < 0.05$.

Using criteria for passing of success on three or more trials on the Model and Photograph tasks, and success on at least one False Belief task, the pattern of passing and failing across all three tasks is shown in Table 3. Performance of most participants conforms to patterns expected from previous research (PPP, PPF, PFF; for the Photograph, Model, and False Belief tasks respectively). However, a few participants in each group show unexpected patterns (PFP, FFP). In line with the above findings, although the predominant pattern for the autism group was PPF, that for the mental handicap group was PPP.

In addition, there was a trend towards an order, or practice, effect. Across both groups, participants who attempted the Model task after the Photo-

Table 2. The Number of Subjects Passing the Photograph, Model, and False Belief Tasks

Task		Number of Trials Passed				
Photograph task	*n*	**0**	**1**	**2**	**3**	**4**
Autism	19	—	—	1	2	16
Mental Handicap	19	—	—	—	3	16
Model task	*n*	**0**	**1**	**2**	**3**	**4**
Autism	19	4	—	1	4	10
Mental Handicap	19	1	2	2	—	14
False Belief task	*n*	**0**	1	**2**		
Autism	19	13	2	4		
Mental Handicap	19	4	10	5		

Table 3. Pattern of Passing and Failing on the Photograph, Model, and False Belief Tasks

Photo[a]	Model[a]	Belief[a]	Autism *n*	Mental Handicap *n*
Pass	**Pass**	**Pass**	4	12
Pass	**Pass**	**Fail**	10	2
Pass	**Fail**	**Fail**	3	2
Pass	**Fail**	**Pass**	1	3
Fail	**Fail**	**Pass**	1	—

[a] Pass = 3 or more successful trials on the Photograph and Model task. [b] Pass = 1 or more successful trials on the False Belief task

graph task performed better than those participants who attempted the Model task first (84.2% vs. 52.6% trials passed, Kolmogorov-Smirnov, $p < 0.10$). On the Photograph task, there was no difference between the success of those participants who attempted this first (94.7%) or second (90.8%).

The Effect of CA and MA

Correlational analysis between the number of trials passed on the Photograph, Model, and False Belief tasks, and CA, VMA, and NVMA yielded only two significant correlations. Performance on the Photograph and Model tasks was related for both the autism (0.69, $p < 0.01$) and mental handicap groups (0.54, $p < 0.01$). To further examine the effects of mental age on performance across the three tasks, the autism and mental handicap groups were subdivided into participants with a VMA less than 54 months, and those with a VMA greater than 54 months. These results are shown in Table 4. With performance on the Photograph and Model tasks near ceiling, there were no differences between the performance of the lower and higher VMA subjects in either group. However, although the higher and lower VMA children with autism perform at roughly the same level (27.3% vs. 25.0% of trials passed, respectively), the children with a mental handicap with a VMA above 54 months performed significantly better than the lower

Table 4. Percent of successful Trials on the Photograph, Model, and False Belief Tasks by VMA

Task	Autism		Mental Handicap	
	VMA < 54m[a]	VMA > 54m	VMA < 54m	VMA > 54m
n	8	11	8	11
Photograph	87.5%	100%	93.8%	97.7%
Model	68.8%	72.7%	78.1%	84.1%
False Belief	25.0%	27.3%	31.2%	68.2%

[a] "m" represents month.

VMA participants (68.2% vs. 31.2% of trials passed, respectively; Fisher's Exact: $p < .004$).

DISCUSSION

The majority of participants from both groups passed the DeLoache Photograph task, and over two thirds the DeLoache Model task, and on neither task were there group differences. However, on the False Belief task, participants with mental handicap were significantly more successful than were participants with autism.

Participants from both groups who failed trials on the Model task commonly returned to the model to look for the coin following an initial unsuccessful search, and had to be prompted to look in the real suitcase, where their search appeared to be random. In fact, 4 participants from the autism group, and 1 from the mental handicap group, failed all four trials of the Model task, whereas all participants from both groups succeeded in at least two trials in the Photograph task. Given the similarity of the materials and instructions, this suggests that the two tasks may indeed tap different representational abilities, and that the participants who failed on all four Model trials failed to appreciate the relationship between the model and the real object.

How do these results compare to those of previous studies? Given that the 31-month-olds in DeLoache's 1991 study retrieved the hidden object on 78% of the "point-picture" trials, the near ceiling performance of both the autism (VMA = 58 months, NVMA = 95 months) and the mental handicap groups (VMA = 56 months, NVMA = 55 months) on the Photograph task was expected. In DeLoache's (1987) original study the 38-month-olds successfully retrieved the hidden object on 77% of the "point-model" trials, compared to only 15% successful retrieval for the 31-month-olds. The retrieval rates for the autism and mental handicap groups of 71% and 82% on the Model trials are close to that of the normal 38-month-olds, and substantially above those of the 31-month-olds in DeLoache's study (1991). Hence, although the mental age of both groups was substantially above that of normally developing children who pass the DeLoache tasks (DeLoache, 1987, 1991), their performance is *relatively* intact, as least in comparison to that of children with autism of similar ability who fail infant-level joint attention and pretend play tasks (Baron-Cohen, 1987; Jarrold, Boucher, & Smith, 1993; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1994). In addition, across both groups, a transfer effect similar to that found by DeLoache (1991) was evident on the Model task, but not on the Photograph task.

The participants with autism passed 26% of the False Belief trials. This is within the band of 20% to 35% of participants with autism who have

commonly been found to pass False Belief tasks (see Baron-Cohen, 1993, for a review). The mental handicap success rate of 53% on the False Belief trials is slightly less than that found in many other similar studies (Baron-Cohen, 1989; Charman & Baron-Cohen, 1992), although the present sample of participants with a mental handicap had a nonverbal mental age (*M* NVMA = 55 months), lower than in some previous studies (Baron-Cohen, 1989: *M* NVMA = 81). In fact, the 11 mental handicap participants with a VMA above 54 months passed on 68% of False Belief trials, similar to that found in previous studies. In addition, participants completed two False Belief trials in this study, whereas many other studies measure performance on a single trial. Using a more generous scoring criteria of passing at least one of the two False Belief trials, 79% of the mental handicap participants, but only 32% of the participants with autism, were successful; chi-square = 4.2, $p < 0.01$.

Another possible explanation of the relatively poor performance of the mental handicap controls is that testing *own* false belief is more difficult than testing *other* false belief (Gopnik & Astington, 1989). However, findings on "self" and "other" false belief questions are inconsistent (Leslie & Thaiss, 1992, Lewis & Osborne, 1990), and the wording used in this study was that employed by Lewis and Osborne (1990), and included the temporal markers that enabled the majority of 3-and-a-half to four-year-olds to pass the "self" false belief question in their study. In summary, comparing these data to the previously reported success rates for normally developing 3- and 4-year-olds on similar False Belief tasks (Leekam & Perner, 1991: 3-year-olds = 25%, 4-year-olds = 74%; Charman & Baron-Cohen, 1992: 3-year-olds = 30%, 4-year-olds = 80%), the performance of the participants with a mental handicap is relatively intact given their mental age, whereas the participants with autism show a significant impairment.

What can we make of the fact that both the participants with autism and those with a mental handicap were able to understand the DeLoache Photo task? DeLoache (1991) would take this as evidence that they understand the symbol-referent relation; Lillard (1993) would take this as evidence that they understand correspondence; whereas Perner (1991, 1993) would take this as evidence that they understand symbolic *as if* relationships. Similarly, the fact that both groups were also able to understand the DeLoache Model task could be taken as evidence of an intact ability to adopt a "dual orientation" (DeLoache, 1991) to objects, or an intact understanding of *non-mental* representations (Leslie & Thaiss, 1992; Charman & Baron-Cohen, 1992). However, over three quarters of the participants with mental handicap, but less than a third of the participants with autism, showed some understanding of the False Belief task. This dissociation suggests that the DeLoache Model task and the False Belief task tap different types of representation, suggesting that the specific deficit found in autism may be accounted for in terms

of a modular Theory of Mind Mechanism (ToMM) (Leslie & Thaiss, 1992; Leslie & Roth, 1993). In addition, the fact that some participants from both groups *passed* the False Belief task whereas they *failed* the Model Task, provides further evidence of the separate development of *mental* and *non-mental* representational abilities.

The explanation provided by Leekam and Perner (1991) for the intact performance by participants with autism on the False Photograph task, that they have learned that photographs do not change, is unlikely to hold for their intact performance on the DeLoache Model task. The participants with autism had a higher mental age than the participants with a mental handicap in this study, and their performance on the Photograph and Model tasks was better, though not significantly so, than that of the mental handicap subjects. However, on the False Belief task, which according to Leslie is the only one of these three tasks to require the use of ToMM, the performance of the participants with autism was significantly below that of the mental handicap controls, and below mental age expectations.

These findings are important for several reasons. First, given the evidence that subjects with autism have a specific deficit, restricted to understanding *mental* representations, rather than a general metarepresentational deficit, this suggests that there may be a specific neural system that might underlie ToMM. There is some evidence that orbito-frontal cortex may play a role in such a system (Baron-Cohen & Ring, 1994; Baron-Cohen et al., 1994). If the modularity thesis is correct, then this raises question about the "initial state" of this module, and how it develops. Whether the origin of ToMM lies in pretend play (Leslie, 1987) or joint-attention (Baron-Cohen, 1991, 1994) will be important issues to clarify. Finally, these studies illustrate how developmental psychopathology affords us an opportunity to better understand both abnormal and normal development (Cicchetti, 1984).

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