

A Nonverbal False Belief Task: The Performance of Children and Great Apes

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A nonverbal task of false belief understanding was given to 4- and 5-year-old children ($N = 28$) and to two species of great ape: chimpanzees and orangutans ($N = 7$). The task was embedded in a series of finding games in which an adult (the hider) hid a reward in one of two identical containers, and another adult (the communicator) observed the hiding process and attempted to help the participant by placing a marker on the container that she believed to hold the reward. An initial series of control trials ensured that participants were able to use the marker to locate the reward, follow the reward in both visible and invisible displacements, and ignore the marker when they knew it to be incorrect. In the crucial false belief trials, the communicator watched the hiding process and then left the area, at which time the hider switched the locations of the containers. When the communicator returned, she marked the container at the location where she had seen the reward hidden, which was incorrect. The hider then gave the subject the opportunity to find the sticker. Successful performance required participants to reason as follows: the communicator placed the marker where she saw the reward hidden; the container that was at that location is now at the other location; so the reward is at the other location. Children were also given a verbal false belief task in the context of this same hiding game. The two main results of the study were: (1) children's performance on the verbal and nonverbal false belief tasks were highly correlated (and both fit very closely with age norms from previous studies), and (2) no ape succeeded in the nonverbal false belief task even though they succeeded in all of the control trials indicating mastery of the general task demands.

INTRODUCTION

There are several tasks commonly used to assess children's understanding that other persons may have false beliefs. The first such task was created by Wimmer and Perner (1983), who called it the Maxi task, modified by Baron-Cohen, Leslie, and Frith (1985), who called it the Sally-Anne task, and it now is generally known as the Location Change task. In this task a child participant and another child watch as the experimenter places a toy in Location A. (Or else the child participant sees this all acted out with puppets.) The other child then leaves the room, at which time the experimenter moves the toy to Location B. The experimenter then asks the participant where the other child will look for the toy—or where she will believe the toy to be located—when she returns. A child who understands that others have beliefs independent of her own will answer that the returning child will believe the toy to be in the original Location A where she saw it hidden, even though it is really in the new Location B.

This task—as well as the other tasks assessing false belief such as the Deceptive Box (Perner, Leekham, & Wimmer, 1987) and Appearance–Reality tasks (Flavell, Flavell, & Green, 1983)—is fairly demanding of young children in at least two ways. First of all, it relies on fairly sophisticated linguistic interactions in which the child is asked what another person will do or even what another person will think or believe. This sometimes involves the use of linguistic structures in which one proposition is embedded in an-

other (e.g., “She will think that X”). Second, it requires the child to imagine a situation that conflicts with what the child knows to be the case in reality. As a number of researchers have argued (e.g., Russell, Jarrold, & Potel, 1994), this might require some skills of inhibition or executive function. These two difficulties of the traditional false belief task have made it somewhat problematic for use with younger children or, at the very least, have created alternative explanations for why children under 4 years of age seldom do well in the task. Indeed, when linguistic demands and inhibition demands are diminished in variations of the basic task procedure, some 3-year-old children appear to perform more skillfully (see Mitchell, 1997, for a review). Three-year-olds also do reasonably well in deception tasks, which at least some researchers take as evidence of false belief understanding and which diminish at least some of the more demanding aspects of the traditional false belief tasks—although the use of deception tasks as a measure of false belief understanding is highly controversial (cf. Chandler, Fritz, & Hala, 1989 and Sodian, Taylor, Harris, & Perner, 1991).

Another limitation of the traditional false belief task is that it cannot be used with nonverbal organisms. This means that we know almost nothing about the false belief understanding of nonverbal children, such as low-functioning autistic children, or of non-

human animals. In the case of nonverbal children, we know of no attempts to assess their understanding of false belief. In the case of nonhuman animals, there are basically two studies, although neither of them aims at the understanding of false beliefs directly. The first involved a nonverbal test of deceptive skills used by Woodruff and Premack (1979) with chimpanzees. In this study, four juvenile chimpanzees learned to indicate to a naive human trainer which of two opaque containers contained food. After learning to do this, two different types of trainers were introduced: (1) a cooperative trainer acted as before, attempting to locate the hidden food and when he did giving it to the subject, and (2) a competitive trainer also attempted to locate the food, but when he found it he kept it and ate it himself. The question was whether the subjects would learn to indicate the correct container for the cooperative trainer but the incorrect container for the competitive trainer. It was found that two of the chimpanzee learned to indicate the incorrect container for the competitive trainer, but they took many dozens of trials to do so—raising the possibility that they had simply learned what to do to get food from each of the two different trainers (Tomasello & Call, 1994).

The second study was by Povinelli, Nelson, and Boysen (1990) and investigated four chimpanzees' understanding of the connection between seeing and knowing. They asked whether chimpanzees could discriminate between a knowledgeable and an ignorant human—based on whether or not the human had seen a hiding event. Three chimpanzees learned to make this discrimination, but they took from 100 to 250 trials to do so and then a few more to make a transfer—raising again the possibility that they were not using an understanding of beliefs to solve the task, but rather they were learning, over many trials, the cue associated with food. The fact that Povinelli, Rulf, and Bierschwale (1994) failed to replicate these results using a different set of somewhat younger chimpanzees provides support for this interpretation, as do subsequent studies, such as Povinelli and Eddy (1996), in which chimpanzees did not seem to understand that others must see their communicative gestures for them to be effective.

One problem with these tasks is that the subject is asked to master both the logistics of the task and to display an understanding of other minds at the same time (e.g., in the pretransfer trials in Povinelli et al., 1990)—and in addition neither of these tasks was aimed at false belief understanding directly. Thus, it could be argued that the reason apes took so long to learn in these tasks is that a certain number of trials are required to master general task demands and lo-

gistics concerning memory for the location of food, keeping track of people and objects simultaneously, and so forth. What is needed is a nonverbal task focused specifically on false belief understanding that gives participants some initial trials in which to master the general task requirements before the critical false belief task is given. The current study was an attempt in this direction. We employed a nonverbal version of the Location Change false belief task, beginning with trials in which the participant demonstrated mastery of the general task requirements. Moreover, in the crucial part of the task, participants did not have to imagine what another individual might believe in some future hypothetical situation, but rather they had to understand something of the beliefs upon which a currently observed behavior was based—and to act on that understanding.

The overall procedure involved a series of tasks, all variations on a hiding-finding game. To begin, a hider hid a reward under one of two identical containers. A barrier occluded the hiding process from the participant, but not from a communicator (see Figure 1). When the barrier was removed, the communicator helped the participant to find the reward by placing a marker on the correct container. In three variations participants then demonstrated their ability: (1) to track the reward to a new location (visible displacement), (2) to track the container marked as containing the reward to a new location (invisible displacement), and (3) to ignore the communicator's marker when it was known to be incorrect (because the participant had seen the reward moved while the communicator was out of the room). Assuming successful completion of these prerequisites, the crucial false belief task was given. In this case, the communicator watched the hiding process and then left the room. The hider then switched the locations of the containers. At this point the participant did not know where the reward was located but, if attentive, knew that the containers had been moved while the communicator was out of the room. The communicator then returned and placed the marker on the box at the location where she saw the food being hidden (recall that the containers are identical). To locate the reward, the participant must reason as follows: (1) the communicator is placing the marker on the container that is where she saw the reward being hidden, (2) the container that was there is now in the other location, and therefore (3) the reward must be in the container at the other location.

Although this task clearly creates for participants a number of information-processing demands not involving false belief understanding, these demands are different from those created by traditional false belief tasks. And in all cases they are demands that

participants have mastered in earlier phases of the experiment, before the crucial false belief task is administered. Of particular note, in the false belief phase of the experiment, participants do not know where the reward is located when the communicator places the marker, and so they do not have to inhibit their knowledge of the reward's true location to behave effectively. They do have to override the communicator's signal when it is known to be incorrect, but they have previously demonstrated the ability to do this in an earlier phase of the experiment.

In the current study we use this new task with two ages of human children, young 4-year-olds and young 5-year-olds, and two species of nonhuman primate, chimpanzees and orangutans. In the study with the human children, a traditional false belief task was incorporated into the same task series so that the difficulty of our nonverbal task could be compared with that of the traditional false belief task. This procedure also allowed us to correlate individual children's performance in our task with their performance in the traditional task and so to validate the new task. Our expectation was that our nonverbal task would show age differences similar to those of the traditional verbal task and be correlated with that task. We did not know what to expect from the nonhuman primates, although our own theoretical predilections suggested that they should have major difficulties with false belief understanding (Tomasello & Call, 1997).

EXPERIMENT 1: HUMAN CHILDREN

Method

Participants

Participants were 14 young 4-year-old children ($M = 4.1$; $range = 4.0\text{--}4.4$) and 14 young 5-year-old children ($M = 5.2$; $range = 5.1\text{--}5.5$) from middle-class families living in a large metropolitan area. They were recruited by telephone from a list containing the names of parents who had volunteered for child development research in general. Parents signed consent forms and children received a small gift for participating. Three 4-year-olds and two 5-year-olds were also run in the task but not included in the final analyses either because they did not cooperate in the task or because they failed to pass the control tasks (see below for details).

Materials

Materials consisted of two identical opaque containers ($12\text{ cm} \times 8\text{ cm} \times 6\text{ cm}$) and a small wooden block ($8\text{ cm} \times 8\text{ cm} \times 3\text{ cm}$) used to designate the box

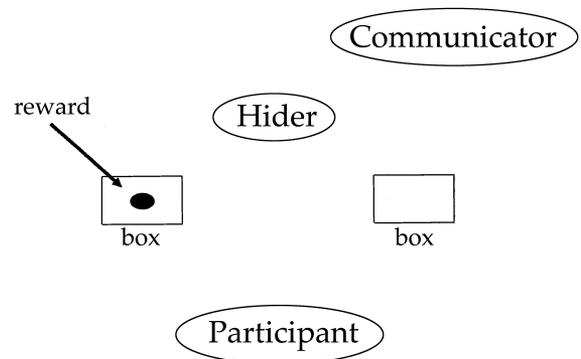


Figure 1 Experimental setting depicting the location of the two experimenters, the participant, and the testing materials.

containing the reward. The reward was always a cartoon "sticker" that children could keep. A barrier formed by cardboard boxes was used to prevent the child from observing the hiding process (see Figure 1).

Procedure

Participants were brought into the experimental room and two adults showed them a collection of stickers, and encouraged them to select 15 or 20 that they preferred. Once the children had chosen their stickers, the adults asked them if they would like to play a hiding-finding game with them. One adult (the hider) sat on the floor behind a barrier formed by cardboard boxes (50 cm in height) and asked a child to sit opposite, facing the hider from the other side of the barrier. The hider showed the children two small containers and told them that a sticker would be hidden in one of them and that the child should try to find it—at which point the sticker could be kept. The second adult (the communicator) sat on a chair behind and slightly to the side of the hider, so as to have a good view of both the child's face and the hider's actions behind the cardboard boxes. The communicator's role was to observe the hiding process and, at the appropriate point in the procedure, to indicate for the child the sticker's location by placing the wooden block (the marker) on top of the appropriate container. The experiment was divided into three phases: pretest, control tests, and false belief tests (in that order). In all phases, the location of the sticker was randomized, with the restriction that it was never placed in the same container for more than two consecutive trials.

Pretest. For each trial the hider began by manipulating both containers behind the partition, placing a sticker inside of one of them. During this process, the

communicator leaned forward and intently observed where the hider was placing the sticker. On some trials, the communicator made a noise or made a comment to attract the child's attention during the baiting process. This was done to help the child to see that the communicator was observing the hiding process. After the hider had readied both containers, they were placed on top of the barrier, approximately 20 cm apart, in full view of the child. At this point, the communicator placed the marker on top of the box containing the sticker and removed it after 1–2 s, making sure that the child had observed this marking action. The hider asked the child, "Where's the sticker?" and permitted one of the containers to be chosen. If the child found the sticker, it could be kept. Otherwise, the hider proposed trying to find another sticker and then conducted the next trial. Each child was administered pretest trials until there were correct responses on three consecutive trials. The main point of this phase of the experiment was to demonstrate for children the communicator's intention to help them in finding the sticker, and the role of the wooden marker in this process.

Control tests. Before testing children in the new false belief task, it was first necessary to test for three prerequisites for successful performance: (1) the ability to follow the sticker as it is visibly moved from one container to the other (visible displacement), (2) the ability to follow the sticker as the container in which it is known to reside is displaced (invisible displacement), and (3) the ability to override the communicator's indication with the marker when it is known to be false (ignore communicator). Children were presented with one trial of each type (in the order 1, 2, 3) and then this procedure was repeated, for a total of two control trials of each type (total = 6). Any child that failed both trials of any one of the control tests was dropped from the study.

First, in the visible displacement control task, the hider hid the sticker and then presented the containers to the participant. The communicator placed the marker on top of the baited container, picked up the marker after 1–2 s, and left the room. The hider then opened both containers and switched the sticker from one to the other in full view of the participant and closed both boxes. The communicator returned to the room, and the hider asked the child to find the sticker. The point of this type of control trial was to make sure that children, after having learned the significance of the marker, could follow the sticker from its original, marked location to a new location—making the container originally marked incorrect. Note also that in this type of trial the communicator's leaving the room is irrelevant to the task, and so these trials also served

to make sure the child would not be distracted by this procedure.

Second, the invisible displacement control task was identical to visible displacement control task, except that instead of changing the location of the sticker, in full view of the child, the hider simply switched the locations of the two containers. Thus, the hider hid the sticker and presented the containers to the child, whereupon the communicator marked the correct container and left the room. The hider then switched the locations of the containers as the child watched (the hider making sure that the child watched). The communicator then returned to the room, and the hider asked the child to find the sticker. The point of this type of control trial was to make sure that children could follow the movement of the sticker as the container in which they knew it to reside was displaced (similar to a stage 6 object permanence task). Note that in this type of trial the child does not see the sticker until after a choice is made; she must therefore discern the sticker's location from the communicator's placement of the marker on a container, and then follow the sticker's displacement as its container is displaced. Note again that the communicator's leaving of the room is irrelevant to the task.

Third, the ignore-communicator control task was identical to the visible displacement control task except that the communicator marked the container after she returned from outside the room. Thus, as before, the hider hid the sticker and presented the containers to the child. In this case, however, instead of marking the correct container as in previous trials, the communicator left the room. The hider turned his head around and watched the communicator leave. The hider then opened the two containers and switched the sticker from one to the other in full view of the child—as in the visible displacement task. Because the sticker's location was changed while the communicator was absent, when she returned to the room she marked the incorrect container, that is, she marked the container at the location she had seen the sticker hidden (and recall that the two containers were identical). After the communicator had removed the marker from the container, the hider presented the containers to the child and asked her to find the sticker. Note that in this task the communicator's leaving of the room is crucial because it explains why she has marked the container that the child knows to be incorrect—because the child, but not the communicator, has just witnessed the sticker being visibly moved from one container to the other.

False belief tests. Each child was administered two versions of the Location Change false belief task: one

verbal and one nonverbal. The verbal test had two trials (presented as a block) and the nonverbal test had four trials (presented as a block). Presentation order of the verbal and nonverbal tests was counterbalanced across children.

The verbal test consisted of an enactment of the Sally-Anne false belief task as operationalized by Baron-Cohen et al. (1985). It maintained the basic structure of the previously administered pretest and control tests; in particular, it was identical to the ignore-communicator control test except that the child was asked about the future behavior of the communicator before she returned to the room. Thus, the hider hid the sticker and presented the boxes to the child; the communicator left the room; and the hider switched the sticker from one box to the other in full view of the child. At this point, with the communicator still out of the room, the hider asked the child which box the communicator would mark. When the communicator returned, the marker was placed on the wrong box (because the sticker was moved while the communicator was gone), and the hider asked the child about the location of the sticker.

The nonverbal test of false belief understanding was the main innovation of the current study. In this task, as in the verbal task (and some of the control tasks) the hider hid the sticker, presented the containers to the child, and the communicator left the room. At this point, the hider switched the locations of the containers, as in the invisible displacement control trials—the crucial difference in this case being that the hider switched the locations of the boxes *before* the communicator had indicated where the sticker was located (i.e., the communicator placed the marker only after returning from outside). Thus, when the communicator returned to the room, the container was marked at the location where it had been hidden, which was incorrect because the containers had been switched while the communicator was out of the room. The hider then asked the child to find the sticker—who, until the moment at which the communicator placed her marker, had no knowledge of the sticker's whereabouts. As in the verbal false belief task, the critical issue was whether the child understood that the communicator believed, falsely, that the sticker was in its original location because the switching of locations had not been witnessed.

Scoring and Reliability

On each trial the child's response was recorded as the container she pointed to or picked up. In the relatively few instances in which the child hesitated or seemed unable to make up her mind, the hider asked

again, "Where's the sticker? Which one?" The hider and the communicator scored the children's responses independently on each trial. The scoring for four 4-year-olds and four 5-year-olds was compared across the two observers and interobserver agreement was found to be 100%, $\kappa = 1.0$.

Results

Pretest

All 4-year-old children and all 5-year-old children except one learned to use the marker as a cue to locate the sticker. Four-year-olds attained the criterion of three consecutive correct trials in an average of 3.9 trials ($SE = .35$; $range = 3-7$), and 5-year-olds attained the criterion in an average of 4.4 trials ($SE = .49$; $range = 3-9$).

Control Tests

During the control tests, three 4-year-old children failed both trials in the invisible displacement test and were dropped from the study. An additional 5-year-old child was also dropped because she became uncooperative during testing. Figure 2 presents the percentage of correct trials in the control tests for both age groups. Overall, both 4- and 5-year-old children passed the three control tests when compared to chance using one-sample *t* tests, 4-year-olds, $t(13) > 4.83$, $p < .001$ one-tailed in all cases; 5-year-olds, $t(13) > 3.30$, $p < .01$ one-tailed in all cases. There were no significant differences between age groups in any of the three control tests. In a 2 (age) \times 3 (task) analysis of variance (ANOVA), there was no effect of age and no interaction. The effect of task was significant,

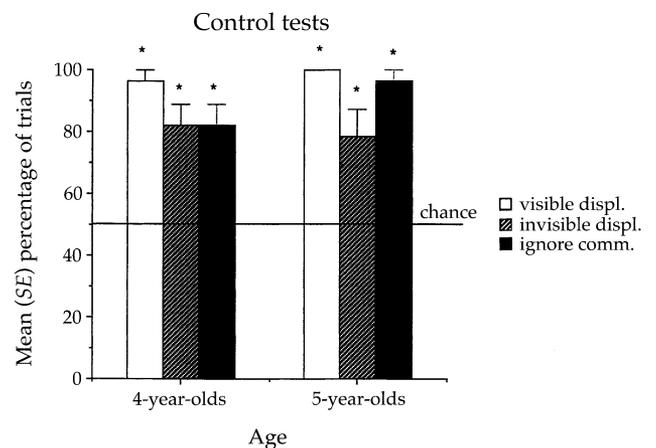


Figure 2 Mean (SE) percentage of correct trials in the three control tests as a function of age group. * $p < .01$.

$F(2, 52) = 4.58, p < .02$, with planned comparisons showing that the visible displacement task was easier than the invisible displacement task, $p < .01$, and marginally easier than the ignore communicator task, $p < .06$ —with these latter two being of equal difficulty.

False Belief Tests

The order of presentation of the false belief tests did not have a significant effect on the children's performance in the verbal or the nonverbal tests, $t(26) < 1.30$ in both cases. Figure 3 presents the percentage of correct trials in the verbal and nonverbal false belief test as a function of age. Overall, 4-year-old children failed to select the correct box at above chance levels in either test, verbal, $t(13) = .29, ns$, nonverbal, $t(13) = .92, ns$. Only five of the children selected the correct box on both trials of the verbal false belief, and only two children selected the correct box on each of the four trials of the nonverbal test (four children on either three or four). In contrast, 5-year-old children selected the correct box at greater than chance levels in both the verbal and the nonverbal tests, verbal, $t(13) = 4.16, p = .001$, nonverbal, $t(13) = 4.84, p < .001$. In this age group, eight of the children selected the correct box on both trials of the verbal false belief, and eight children also selected the correct box in each of the four trials of the nonverbal test (11 children on either three or four). A 2 (age) \times 2 (test) ANOVA revealed a main effect for age, $F(1, 26) = 10.34, p < .01$, but no effect for test and no interaction. Planned comparisons indicated that older children performed significantly better than younger children in both the verbal, $p < .05$, and the nonverbal tests, $p < .01$.

One possibility is that the children who were suc-

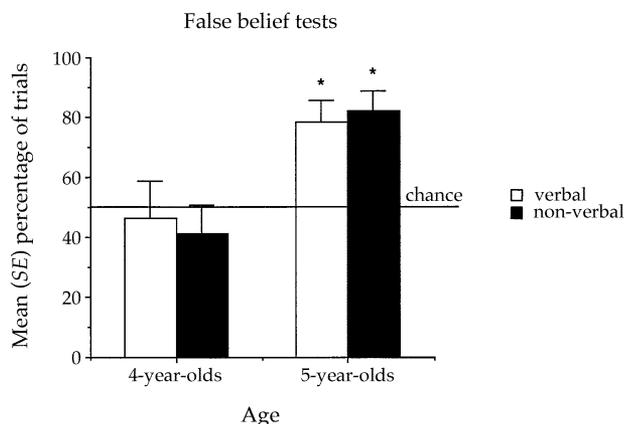


Figure 3 Mean (SE) percentage of correct trials in the verbal and nonverbal false belief tests as a function of age group. * $p < .01$.

cessful in the nonverbal false belief task learned this skill over trials as they observed that for these trials the container without the marker was correct. This interpretation might plausibly hold for some of the 14 4-year-olds, whose performance as a group improved over trials, Friedman test: $\chi^2(3, N = 14) = 6.56, p < .05$. However, the three children in this age group who were correct on the first trial were also correct on both verbal false belief trials, suggesting that they were not simply learning to use the marker as a kind of negative cue. Even more important are the older children. Of the 14 5-year-olds, 11 were successful on the very first nonverbal false belief trial, and as a group these children's performance did not improve across trials, Friedman test, $\chi^2 = ns$. As another check of this type, the performance of the 5-year-olds was better than that of the 4-year-olds when just the first two trials were compared, $t(26) = 3.04, p < .01$.

Of most importance for validating the nonverbal false belief task was its relation to the verbal false belief task. Table 1 presents a matrix relating individual children's performance in the two tasks. There is a significant relation between these two tests, $\chi^2(4, N = 28) = 15.06, p = .004^1$ indicating that when the children scored high in one of the tests they also scored high in the other, and conversely, when the children scored low in one test they also scored low in the other. Perhaps most impressively, there were no children who scored perfectly on one test but got 0 on the other, whereas there were nine children who scored either perfectly on both tests or got 0 correct on both tests, Fisher test, $p < .001$. Corroborating this analysis, the Pearson Product Moment correlation between the two measures of false belief understanding (using the 3×3 matrix as described in footnote 1) was $.69, p < .001, df = 26$ (using the full matrix the value was $.65, p < .001$). If the relation is investigated using only the first two trials of the nonverbal false belief task, there is still a significant relation, $\chi^2(3, N = 28) = 9.59, p < .05$, and $r = .47, p < .01$.

As another means of validation, the performance of the current children was compared to that of children in other studies using the standard false belief task. (Studies included are all published studies using one or another version of the Change Locations task that reported mean percent correct for particular age groups. In studies in which two methods are used, the more "standard" version is plotted in Figure 4—because this is the method most comparable to our own.) Figure 4 presents the average percent correct

¹To avoid empty cells the χ^2 was done on a 3×3 matrix in which scores on the nonverbal false belief task were collapsed into the three categories: 0–1; 2; 3–4.

Table 1 Relation Between the Frequency of Correct Responses in the Verbal and Nonverbal False Belief Tests for the Children in Study 1

		Nonverbal False Belief				
		0	1	2	3	4
Verbal False Belief	0	3	2	1	0	0
	1	1	2	1	1	4
	2	0	0	3	4	6

for children in the verbal false belief task across a number of published studies and compares it with the results of the present study. In general, it is clear from this comparison that the children in the current study performed at levels comparable to those in previous studies using a similar verbal false belief task. This is somewhat surprising because our verbal task involved children in the game more actively than most studies, and the nonverbal test eliminated linguistic variables. On the other hand, it may speak to the robustness of children's difficulties with false belief tasks in which they must overcome a discrepancy between their own knowledge and that of others—and the relative triviality of many task variables. It is also important in interpreting children's performance to note that there was no correlation between children's performance on the control tasks and their performance on the nonverbal false belief,

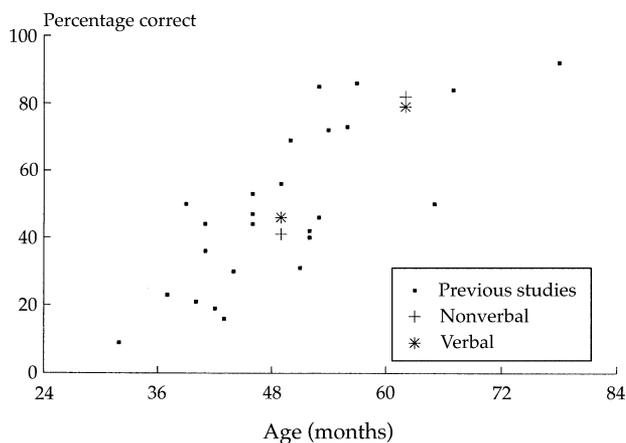


Figure 4 Percentage of correct responses in the verbal and nonverbal tasks of the present study compared to the results of previous false belief studies as a function of age. (Sources: Baron-Cohen et al., 1985; Clements & Perner, 1994; Lewis, Freeman, Hagestadt, & Douglas, 1994; Moore et al., 1995; Robinson & Mitchell, 1992, 1994, 1995; Siegal & Beattie, 1991; Wellman & Bartsch, 1988; Wimmer & Perner, 1983).

task, all p values $>.20$. This means that it was not the case that general skill with tasks of this type was the major variable determining children's performance in the key false belief task.

Discussion

This study had two major findings. The first was simply that the ability to solve both verbal and nonverbal false belief tasks increased with age. Only a minority of 4-year-old children clearly passed either task, whereas most 5-year-old children clearly passed them both. In general, children's overall performance accorded very well with previous studies in which a standard false belief task was given to children in this age range. It is also noteworthy that the current tasks differed from standard false belief tasks in a number of task variables, indicating further the robustness of false belief understanding under different task conditions. The use of control tests in the current study indicated that children who failed did not do so because they were unable to follow visible or invisible displacements, because they had inadequate memories, or because they were unable to overcome the communicator's advice when they knew it to be incorrect. The fact that the most successful 5-year-olds and the most unsuccessful 4-year-olds both did quite well on the control tasks (with no correlation between control and false belief tests within either age) also argues that the key variable predicting children's performance was their level of false belief understanding.

The most important finding of the current study was the strong correlation between the verbal and nonverbal versions of the false belief test. This was assessed in several ways, and in all cases the relation was quite strong. Indeed, no child performed extremely well on one task but poorly on the other. It should also be noted that the magnitude of the correlation between the tasks in the present study closely resembles the magnitude of the correlations between different measures of false belief (i.e., deceptive box, appearance-reality, and representational change) as reported in other studies (Astington & Gopnik, 1988; Moore, Pure, & Furrow, 1990). Taken together, the concordance with previous studies both in the age of emergence and, more importantly, in the correlation between the verbal and nonverbal tasks used in the present study suggests that our nonverbal test is a valid measure of false belief understanding in preschool age children.

EXPERIMENT 2: APES

In a second experiment we administered the tests from Study 1 to nine great ape individuals, with the

exception that the verbal false belief task was not given. Because of the nature of ape motivational, attentional, and learning abilities, and the physical housing of the animals, a few procedural modifications were made. Most importantly, the reward for which the apes searched was food (not a sticker), the number of trials administered during all phases was greater, and the communicator did not leave the room but moved across the room and turned her back to the subject and hider. Also, the invisible displacement control test had to be modified in response to the subjects' difficulties with it.

Method

Participants

Two adult orangutans and five adult and subadult chimpanzees housed at the Yerkes Primate Center participated in this study (see Table 2). All of them had previously participated in several other cognitive studies, most importantly one in which they had learned that a marker on top of a container indicated food in that container. One orangutan, Chantek, had been raised early in life by humans and had been taught a variety of human-like skills, including some aspects of American Sign Language (see Miles, 1990, for details). Two additional orangutans were run for parts of the study but were not included in the final analyses—one because she was moved from the Yerkes center during testing and one because he did not pass the required control tests (see below for details). Animals were housed in small group cages with indoor and outdoor areas. For testing, individuals were isolated in either the indoor or outdoor portion of their cage. Animals were fed on the normal schedule throughout all phases of testing.

Materials

The experimenter used the same two opaque containers and the wooden block from the previous ex-

periment. The two containers rested on a wooden platform situated between the subject's cage and the experimenter. A cardboard screen was used as a barrier to conceal the baiting from the subject. A variety of food rewards were used based on each individual animal's predetermined food preferences (mostly grapes and oranges).

Procedure

As in Study 1, there were three main phases: pretest, control tests, and false belief test. Again, in all phases the location of the food was randomized, with the restriction that it was never placed in the same container for more than two consecutive trials. One difference was that in this study the nonhuman primates needed an initial habituation period to get used to the testing situation and to learn the roles of the two experimenters, especially the fact that the communicator was there to help them find the food.

Habituation. Before testing began, subjects were habituated to the experimental setting and taught some of the logistics of the present experiment. One experimenter (the hider) sat facing the subject with the apparatus between the hider and the subject. The hider was separated from the subject by the cage fence with the apparatus beyond the subject's reach. A second experimenter (the communicator) stood behind and slightly to the side of the hider, with a good view of the subject and the apparatus. In this habituation period, the hider placed the screen in front of the apparatus (blocking the subject's view) and placed a piece of food under one of the two containers. The hider then removed the screen and the communicator, who had been watching the process, lifted the container to reveal the location of the food to the subject (replacing the container when finished). The hider then pushed the apparatus against the fence and allowed the subject to select one of the boxes by touching it. Subjects were then given the contents of the container they had chosen (if any). Each subject received habituation sessions (18 trials per session) until its performance was above chance for two consecutive sessions. All subjects achieved this criterion in the first two sessions.

Pretest. In a previous experiment subjects had learned to use the marker to select which box contained food after a delay period (delayed discrimination). Because some time had passed since subjects took part in this experiment, we retested subjects on their ability to use the marker to find a piece of food after the marker had been removed for a 5-s delay period. On a given trial the hider manipulated both containers behind the partition and placed a piece of

Table 2 Orangutans and Chimpanzees in Study 2

Subject	Age (Years)	Sex	Testing Procedure
Orangutans			
Chantek	19	Male	Original
Teriang	24	Male	Modified
Chimpanzees			
Cissie	20	Female	Modified
Ericka	23	Female	Modified
Jesse	14	Female	Modified
Sonia	37	Female	Modified
Travis	7	Male	Modified

food inside one of them. During this process, the communicator leaned forward and intently observed where the hider was placing the food. On some trials, the communicator made a noise (e.g., clapping hands) to attract the subject's attention and show that the communicator was looking at the baiting process. After the baiting, the hider removed the screen, revealing the two containers, and the communicator placed the marker on top of the baited container, removing it after the subject had witnessed his action. The hider pushed the apparatus against the fence and waited for the subject to select one of the containers. As soon as the subject touched a container, the hider pulled back the apparatus and gave the contents of the touched container (if any) to the subject. Each subject received habituation sessions (18 trials per session) until its performance was above chance for two sessions in a row. All subjects achieved this criterion, again taking from two to five sessions.

Control tests. As in Study 1, the aim of this phase of the experiment was to establish that subject possessed the ability: (1) to follow the food as it is visibly moved from one container to the other (visible displacement), (2) to follow the food as the container in which it is known to reside is displaced (invisible displacement), and (3) to override the communicator's indication with the marker when they know that the food is in the other container (ignore communicator).

In the visible displacement test, the hider hid the food and presented the containers to the subject. The communicator placed the marker on top of the baited container (making sure that the subject noticed this), picked up the marker after 5 s, turned around, and walked to the end of the experimental room, standing with back turned in sight of the subject. Note that this procedure is different from that used with children in which the communicator actually left the room; however, the logistics of the housing of the animals dictated this modified procedure. Once the communicator had reached his predetermined position, the hider opened both containers and switched the food from one to the other in full view of the subject. The communicator returned to the position behind the hider, who pushed the apparatus within the subject's reach to permit the selection of one of the containers.

The invisible displacement control task was identical to visible displacement control task except that instead of changing the location of the food, in full view of the subject, the hider simply switched the locations of the two containers. Thus, the hider hid the food and presented the containers to the subject, whereupon the communicator marked the correct container, turned around, and walked across the room. The hider then switched the locations of the contain-

ers as the subject watched (the hider making sure that the subject watched). The communicator then returned, and the hider pushed the apparatus to the subject to make a selection. Note again that in this type of trial the subject does not see the food until after a choice is made; it must therefore discern the food's location from the communicator's placement of the marker on a container and then follow the food's displacement as its container is displaced.

The ignore-communicator task was identical to the visible displacement task except that the communicator marked the container after returning from across the room—which meant that the incorrect one was marked because the food was moved while the communicator's back was turned. Thus, as before, the hider hid the sticker and presented the containers to the subject. In this case, however, instead of marking the correct container as in previous trials, the communicator crossed the room and stood with back turned. The hider turned around and watched the communicator leave. The hider then opened the two containers and switched the food from one container to the other in full view of the ape—as in the visible displacement task. Because the food's location was changed while the communicator was absent, upon returning to the testing area the incorrect container was marked; that is, the container was marked at the location the communicator had seen the food hidden (and recall that the two containers were identical). After the communicator had removed the marker from the container, the hider presented the containers to the subject for selection.

Four subjects (two orangutans and two chimpanzees) were given a total of 18 trials of each of these control tests in a random order (three sessions of 18 trials each, 6 trials of each type in each session). All subjects were above chance in the visible displacement and ignore communicator tests, but only one (the orangutan Chantek) passed the invisible displacement test. Subjects seemed to have trouble identifying the correct container when it was displaced and they had not seen the reward (even when they were given extra trials of this type). As a consequence, we decided to modify all the control tests by simply leaving the marker on the container during the subject's selection.

Modified control tests. Because one of the subjects (Chantek) passed all the control tests, he was not given any modified control tests. The three subjects who had difficulties were administered modified versions of the visible displacement and ignore communicator tests and were given two modified versions of the invisible displacement test: marker and no-marker. The remaining three subjects were given the

modified versions of all control tests. The modified versions of the visible displacement and ignore communicator tasks were identical to the original tasks except that the marker was left on the container as the subject made its choice.

In the marker version of the modified invisible displacement task, the hider hid the food, the communicator placed the marker on the correct container and left it there and walked to the end of the room. Everything else was as in the original version: The hider switched the containers' locations in full view of the subject, the communicator returned, and the hider pushed the apparatus to the subject. In the no-marker version of the modified invisible displacement test, the difference was that after the hider had hidden the food, the communicator lifted the correct box revealing the food and walked to the end of the room, leaving no marker. The hider then switched the containers' locations in full view of the subject, the communicator returned, and the hider pushed the apparatus to the subject.

False belief test. As in Study 1, the critical test was the test of false belief understanding. In these trials, as in some of the control tasks, the hider hid the food, presented the containers to the subject, and the communicator turned and walked across the room to stand with back turned to the subject (the hider turned around and watched the communicator leave). At this point, the hider switched the locations of the containers, as in the invisible displacement control trials (no marker)—the crucial difference in this case being that the hider switched the locations of the containers *before* the communicator had indicated where the sticker was located (i.e., the communicator placed the marker only after returning). Thus, when returning to the testing area, the container was marked at the location where the communicator had seen it hidden, which was incorrect because the containers had been switched while the communicator was across the room with back turned. The hider then pushed the apparatus forward allowing the subject to select one of the boxes. For the six subjects who had received the modified control tests, the marker remained on the container; for Chantek the marker was placed and removed as it was for the children in Study 1. Subjects received a total of four false belief trials, all in a single session.

Follow up. Immediately after subjects had completed the four nonverbal false belief trials of the previous phase, subjects were presented with additional trials from four different tests: the three modified controls (visible displacement, invisible displacement—no marker, and ignore communicator) and the false belief test—16 of each type for a total of 64 trials.

Table 3 Frequency Distribution of Apes in the Nonverbal Test as a Function of the Percentage of Correct Trials and Test Phase (Study 2)

Phase	Nonverbal False Belief (%)			
	0–25	26–50	51–75	76–100
Test	6	1	0	0
Follow-up	4	2	1	0

These additional trials were conducted (1) to verify that subjects were still able to pass the control tests and (2) to find out if subjects would improve on the false belief task with additional experience. A total of four sessions with 16 trials per session were conducted (64 trials total). During each session, four trials of each type were presented in a randomized order.

Results

Habituation and Pretest

As reported, all seven subjects met the criteria in the habituation test, choosing the container where they had seen the food disappear, in the minimum number of sessions (two). In the pretest, in which they had to learn to use the marker to find the food, they performed at above chance levels within two to five sessions (average of 3.2 sessions for each, representing an average of approximately 60 trials per subject). Subjects selected the container with the marker on an average of 87% of the trials ($SE = 2.8$) in their last two sessions, which is well above chance, $t(8) = 13.33, p < .001$.

Control Tests

One orangutan (Chantek) passed all three control tests in their original form, Binomial test, $p < .05$ in all cases. Three subjects (the orangutan Teriang and the chimpanzees Ericka and Travis) passed both the visible displacement test and the ignore communicator test, Binomial test, $p < .05$ in all cases, but failed the invisible displacement task. Because additional trials did not improve their performance, they were given modified versions of this task—as were the remaining three subjects. Figure 5 presents the percentage of trials in which the six subjects given the modified versions of the invisible displacement control test (one orangutan and five chimpanzees) selected the baited container on the four types of control tests. Subjects selected the baited container on all four tests at above chance levels, $t(5) > 14.82, p < .001$ in all cases, averaging close to 90% correct.

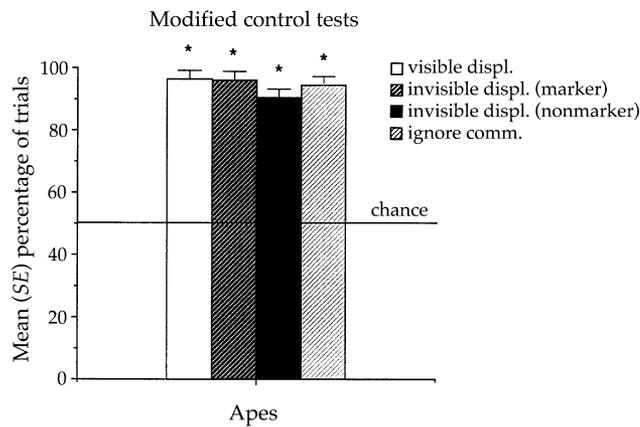


Figure 5 Mean (SE) percentage of correct trials in the four modified control tests. * $p < .01$.

False Belief Test

In the false belief test, subjects selected the correct container on only 10.7% ($SE = 7.4$) of the trials; this is significantly *below* chance, $t(6) = 5.28$, $p = .002$. Specifically, five of the seven subjects chose the correct container on zero out of four trials, one subject chose the correct container on one trial, and one subject chose the correct container on two trials (with chance being two out of four correct). This below chance result is attributable to the subjects choosing the marked container, despite the fact that they had been able in the control trials to ignore the marker when they had seen the food itself moved to the unmarked container.

Follow Up

The follow-up trials replicated the overall results of the main part of the experiment in almost every detail (see Figure 6). Subjects selected the correct container at above chance levels in all three control tests, $t(6) > 6.94$, $p < .001$ in all cases. However, they continued to select the incorrect box at above chance levels during the false belief trials, $t(6) = 3.74$, $p = .01$. Specifically, out of 16 false belief trials, four subjects selected the correct container on zero out of four trials, two subjects chose the correct container on five out of eight trials, and one subject chose the correct container on nine trials. To assess the learning explanation in these additional trials, the 16 false belief trials were divided into blocks of four on the basis of their order of presentation. No effect of order was found, Friedman test, $\chi^2 = ns$.

Discussion

None of the apes passed the false belief test despite the fact that they had clearly passed the control tests.

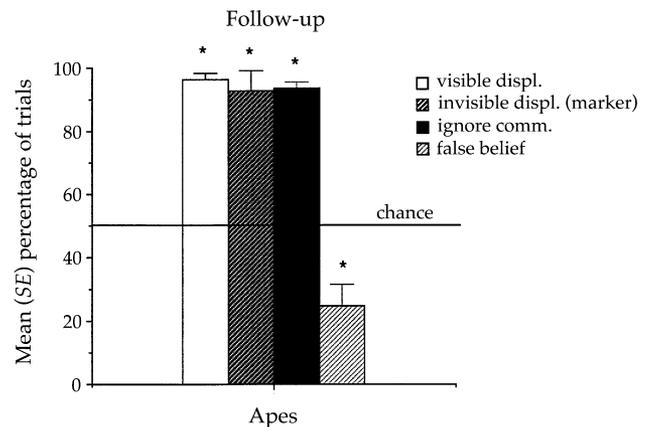


Figure 6 Mean (SE) percentage of correct trials in the three modified control tests and the false belief test during the follow up phase. * $p < .01$.

In these control tests, subjects had shown their ability to track visible and invisible displacements, to remember the location of food, and to ignore the experimenter's marking behavior when the subject knew it to be wrong. This failure in the false belief test is even more compelling if we consider that subjects were given an opportunity to learn the task by presenting them with multiple trials in the follow up. The overall conclusion is thus that this study provided no evidence to support the notion that chimpanzees and orangutans have an appreciation of false belief in others.

Negative results are always difficult to interpret and the subjects' failure may be explained in a number of ways. First, it is conceivable that although the control conditions tested the prerequisites for the false belief task separately, it is possible that the combination of these prerequisites amounted to a different level of cognitive complexity. For instance, recall that three of the four pilot subjects (two chimpanzees and one orangutan) in the training phase failed one of the original invisible displacement control tests, and, as a consequence, modified versions of this control test were given. Recall that in that original invisible displacement control test, subjects had to track the displacement of food that they had never seen in a container that was marked only temporarily (i.e., the marker was placed on it to indicate the location of the food, but then removed). If subjects were not able to solve the problem of tracking the displacement of the food under these circumstances, they could not solve the false belief problem either. And, indeed, Call and Rochat (1997) recently found that some orangutans have trouble tracking moving rewards under some circumstances. However, there is one finding of the current study that contradicts this possibility. One

of the four original subjects (Chantek) passed the very difficult invisible displacement control problem—requiring him to track the location of food he had never seen directly as its container was displaced (the food's container having been indicated for him briefly with the marker)—but he clearly failed the false belief test nevertheless.

Another possibility that may account for the apes' failure is the fact that in the modified false belief procedures used, the marker was maintained on the container. Given that a subject's success on the false belief test rested on his or her ability to ignore the marker placed by the communicator, it is possible that the marker's continuous presence exercised a powerful influence on subjects' choices. However, two findings contradict this possibility. First, subjects had no problem ignoring the marker when they had seen the location of the food and the marker's location contradicted this information (i.e., in both the visible displacement and ignore communicator control tests). Still, it is possible that subjects worked with the following strategy: if the food is seen, go where it was last seen; if the food is not seen, go with the marker. However, there is a second finding that contradicts this possibility. Chantek was given the same version of the task as the children in Study 1 (the communicator always removed the marker immediately after placing it—so that it could not have been a distraction), and he still chose the marked container more than the correct container in the false belief task.

A third possibility is that the communicator stayed in the experimental room with her back turned to the subject—whereas in Study 1 the communicator left the room. We were forced to use this procedure because the set-up of the experimental room did not allow the experimenter to leave the room quickly, potentially imposing an excessive memory load on the subjects. Our choice to use the communicator with his or her back turned was based on recent studies showing that when producing a gesture, chimpanzees and orangutans are sensitive to the attentional state (i.e., bodily orientation) of their potential recipients. Tomasello, Call, Nagell, Olguin, and Carpenter (1994) found that young chimpanzees only used purely visual gestures (i.e., devoid of sound or tactile stimulation) when their recipients were bodily oriented toward them and therefore potentially able to visually perceive those gestures. Call and Tomasello (1994) and Povinelli and Eddy (1996) found that orangutans and chimpanzees, respectively, gestured preferentially to experimenters that were facing them as opposed to facing away from them. Thus, at the very least, previous studies have shown that humans across the room with their backs turned

are not perceived as potential communicative partners for apes.

A fourth possibility is that chimpanzees and orangutans do not understand the mental states of humans, but they do understand the mental states of conspecifics. Unfortunately, the structure of the current task did not allow us to test the apes with conspecifics for the hider and communicator. Although at this point it is impossible to know how much weight to place on this argument, if the human case is accepted as a valid reference point, the attribution of mental states to species other than one's own is not an especially difficult or problematic procedure. In fact, in some instances human children attribute mental states not only to other species but even to inanimate objects (Piaget, 1929).

Finally, there is the possibility that the apes may not understand that others have knowledge and beliefs, and, consequently, they may not be capable of solving the false belief task. (A variation on this hypothesis is that apes understand that others have beliefs, but they do not understand that beliefs may be formed through the witnessing process; that is, they do not understand that seeing leads to knowing. However, the one condition from the studies of Povinelli and Eddy (1996) in which chimpanzees acted as if they might understand that seeing leads to knowing—a human facing them directly—is precisely the arrangement used in the current study, and subjects failed nonetheless.) This is our preferred hypothesis given that a number of recent studies have reported negative evidence in nonhuman primates and other related studies have raised some serious doubts about the validity of the studies reporting positive evidence. The only two studies that have produced positive evidence in chimpanzees are Premack (1988) and Povinelli et al. (1990)—which are basically the same task (with the latter a much fuller report). The main problem, as noted in the introduction, is that in the Povinelli et al. study, chimpanzees took literally hundreds of trials to get to a level of 70% correct in discriminating a knowledgeable and an ignorant human. Povinelli and colleagues recognized this limitation and emphasized that the critical test was their transfer test—in which the human was ignorant for a different reason (instead of leaving the room, he placed a bag over his head so he could not see the hiding process). Chimpanzees performed at above-chance levels in this transfer task, but it took them several trials to do so. Povinelli (1994) reported that the chimpanzees' choices were random in the first two trials and only reached 65% correct after five trials. This failure to immediately transfer opens the possibility of other explanations involving cue learning, learning set formation, and the like, that do not require the un-

derstanding of knowledge and beliefs in others. Furthermore, in a study with younger chimpanzees, Povinelli et al. (1994) failed to replicate chimpanzees' ability to discriminate a knowledgeable from an ignorant human in the first place, and Povinelli and Eddy (1996) find that they cannot even recognize that seeing leads to knowing at all.

GENERAL DISCUSSION

In the current study we had two main goals: one concerning the children and one concerning the apes. First, in Study 1, we attempted to validate a nonverbal test of children's false belief understanding. In terms of face validity, we should point out first that the test was preceded by several control tests in which children had to demonstrate their ability to handle various task demands concerning memory, attention, and so forth, to rule out these as explanations for children's performance. Thus, failure in the test of false belief understanding was not easily attributable to extraneous task demands. More importantly, 4- and 5-year-old children were given both the nonverbal task and a traditional, verbally based test of false belief understanding, and the correlation between them was quite high—in the same range as correlations reported for the interrelations among other versions of false belief tasks (i.e., location change, deceptive box, appearance–reality, and representational change). Furthermore, the level of difficulty of both our verbal and nonverbal tasks were equivalent to those of other researchers investigating children in this same age range. Overall, then, we believe that our nonverbal false belief task measures the same underlying social cognitive ability as traditional, verbally based false belief tasks.

Given that the traditional task is more easily solved by children when some small modifications are made, it is possible that the current task could be made easier for nonverbal children in several ways (we were unable to make these changes in the current study because we wanted to administer the task in identical ways to children and apes). First, following Chandler and Hala (1994), children could themselves move the containers when the communicator is outside the room—thus making the location change more salient for them. Second, some more salient linguistic and nonverbal cues about the social situation might be given, for example, saying things like “Let's trick her,” accompanied by a “tricky” facial expression and laugh, when the communicator is outside the room (again we could not do this here because of the possibility of differential understanding by children and apes). Finally, for any children for whom memory is

an issue, the marker could be left on the correct container throughout the procedure (as in the modified tasks for the apes), although this might make inhibition of knowledge a more serious issue.

These possible modifications raise the issue of how the current results compare to those of Clements and Perner (1994), who used a preferential looking procedure to determine that some 3-year-old children have adult-like expectations about the actions of other animate beings in situations that might involve false belief. As with all comparisons of studies in which subjects simply look and those in which they produce intentional actions requiring active choices among alternatives, we are presumably dealing here with different levels of understanding—in this case of the intentional and mental lives of others. We are not sure how to characterize the difference except to say that what we are measuring concerns that knowledge of others on the basis of which apes and children can make an adaptive response.

The second goal was to determine whether great apes have an understanding of the false beliefs of others as operationalized in the nonverbal false belief task. We found that not one of the seven apes tested showed any signs of such an understanding. There are several possible reasons for this negative result, as discussed above, among them: the general information processing demands of the task, problems with inhibition, the species of the experimenters (human), and procedural differences with the child version of the task. However, each of these potential explanations comes into conflict with various aspects of the data. Moreover, our negative results are consistent with a growing body of evidence showing that apes may not have social cognitive abilities identical to those of humans. Studies in which apes have supposedly demonstrated an understanding of the beliefs of others may be more parsimoniously interpreted as instances of associative learning (see above and Tomasello & Call, 1997, for a review).

Because of our results and all of the other converging evidence, therefore, our hypothesis is that apes do not have a “theory of mind” in the sense of understanding the false beliefs of others. This does not mean, however, that apes do not have sophisticated cognitive and social cognitive abilities. They have their own ways of doing things, adapted to their own ways of life. For example, in the domain of social cognition, they follow the gaze of conspecifics (Tomasello, Call, & Hare, 1998), they coordinate their behavior in hunting various prey (Boesch & Boesch, 1989), they communicate with groupmates using both vocalizations and gestures (Tomasello & Call, 1994), they learn from one another socially (Whiten & Ham,

1992), and they join forces with one another in contests for dominance and resources (see Harcourt, 1992, for a review). These all involve understanding complex social situations and creating sophisticated social strategies for dealing with them.

But the human version of primate social cognition—in which individuals understand the behavior of others in terms of, among other things, their beliefs about the world—has some special qualities. These qualities make for an especially complex social life, indeed a complex cultural life, in which individuals live in the context of their beliefs about other people's beliefs. If the current results are accurate, the social-cognitive skills that make for such complex social and cultural interactions must have arisen in the human lineage only after human beings split from chimpanzees some 6–8 million years ago. There are important dimensions of social cognition that do not involve the understanding of beliefs, however (e.g., the understanding of intentions and attention), and the status of these types of social cognition in the various species of nonhuman primate is still very controversial (Tomasello & Call, 1997). Characterizing the precise nature of nonhuman primate social cognition and how it relates precisely to different types of human social cognition thus remains a challenge for future research.

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