Theory of Mind Development in Deaf Children: A Nonverbal Test of False-Belief Understanding

Berta Figueras-Costa
Russell Cairns Unit, Radcliffe Infirmary

Paul Harris
University of Oxford

Our aim in this study was to investigate whether previous findings pointing to a delay in deaf children's theory of mind development are replicated when linguistic demands placed on the deaf child are minimized in a nonverbal version of standard false-belief tasks. Twenty-four prelingually deaf, orally trained children born of hearing parents were tested with both a verbal and a nonverbal version of a false-belief task. Neither the younger (range: 4 years 7 months–6 years 5 months) nor the older (range: 6 years 9 months–11 years 11 months) children of the final sample of 21 children performed above chance in the verbal task. The nonverbal task significantly facilitated performance in children of all ages. Despite this facilitation, we observed a developmental delay: only the older group performed significantly above chance in the nonverbal false-belief task, even though the younger children were at the average age when hearing children normally pass standard false-belief tests. We discuss these findings in light of the hypothesis that language development and conversational competence are crucial to the acquisition of a theory of mind.

It makes good evolutionary sense to think that humans have evolved a neurocognitive mechanism specifically designed to extract information about covert mental states from other people's overt actions and to use this information to anticipate their future behavior (Baron-Cohen, 1994; Byrne & Whiten, 1988; Humphrey, 1984). This "theory of mind," as it is called in recent experimental literature, is surely of great survival value.

The existence of such a neurocognitive mechanism is supported not only by arguments of evolutionary plausibility. Mental state attribution is a universal feature of human reasoning (Baron-Cohen, 1995), and empirical data suggest that the pace of theory of mind development in children is similar across cultures (Avis & Harris, 1991). Both these considerations favor the biological origin of our mental state inference skills. The hypothesis that we might be endowed with a theory of mind neurocognitive mechanism is also upheld by the finding that individuals with autism—a disorder with a strong genetic component (Rutter, 1991) and a presumed neurological component (Baron-Cohen, 1995; Fletcher, Happé, Frith, & Baker, 1995; Happé et al., 1996)—perform poorly on tasks of mental state attribution (Baron-Cohen, Leslie, & Frith, 1985; Baron-Cohen, 1989a, 1991).

Nevertheless, the view that emphasizes the biological roots of our mentalizing skills is not incompatible with an acknowledgment of the important role played by exogenous factors in the normal development of a theory of mind. Social interaction is probably crucial in children's acquisition of mental state attribution abilities; the capacity to communicate and to exchange information with others through language is purportedly essential in fostering theory of mind development

The research contained in this article was conducted while the first author was at the Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD. We thank all the children who participated in this study and their families. We are grateful to the following schools and educational centers for their willingness to collaborate in this research and their facilitation of the testing procedure: Escola St. Ot, Escola El Sagrer, and CEE Josep Pla (Barcelona); CREDA Comarques I (Vic); CREDA Vallès (Sabadell); CREDA Baix Llobregat; CEIP Montbou (Igualada); and EEE La Maçana (Girona). We thank Dr. N. Silvestre for her encouragement and her vital help in seeking the schools' support, and Kirsty Barlow for useful discussions. We especially thank Virginia Costa for being an excellent "hider" and an enthusiastic assistant. Correspondence should be sent to Berta Figueras-Costa, Francesc Carbonell 22, Barcelona 08034, Spain (e-mail: bertafigueras@yahoo.com).

(Harris, 1996, 1999; Segal, 1998; Smith, 1996). Supporting this theoretical link between language and theory of mind development is empirical evidence that suggests a strong correlation between the two (Jenkins & Astington, 1996, 1999).

One of the main symptoms of the autistic condition, impaired communication (Frith, 1989; Happé, 1994), could provide an additional explanation as to why the neurocognitive mechanism devoted to understanding other minds does not function normally in autistic individuals: it lacks the conversational input necessary for its normal development. Not only can this "conversational hypothesis" complement the neurological approach to autism, it can also accommodate the finding of at least one other group of individuals who likewise tend to fail theory of mind tasks: deaf children born of hearing parents (Deleau, 1996; Peterson & Siegal 1995, 1998, 1999; Russell et al., 1998; Steeds, Rowe, & Dowker 1997). Deaf children born of hearing parents perform poorly in tasks tapping mental state attribution capacities, according to the conversational hypothesis, because of their delayed exposure to conversation. If born to deaf parents (who are native signers), deaf infants do not undergo an initial period of restricted linguistic interchange. Consequently, they later follow a normal pattern of theory of mind development and succeed in false-belief tasks at the same age as hearing children do (Courtin & Melot, 1998; Peterson & Siegal, 1999). By contrast, prelingually deaf children born within hearing families (where there is rarely a fluent signer by the time of the deaf infant's birth) suffer from a delayed exposure to conversation and linguistic interaction, which results in their retarded theory of mind development.

However, the results obtained in the studies that have investigated deaf children's theory of mind development are open to an alternative explanation that might account equally well for the delay. An underlying, fully developed theory of mind could be masked by deaf children's difficulties with language in the course of the testing procedure.

All the assessment methods (Baron-Cohen, 1991; Baron-Cohen et al., 1985; Flavell, Flavell, & Green, 1983; Leekam & Perner, 1991; Perner, Frith, Leslie, & Leekam, 1989; Wimmer & Perner, 1983) used to tap mental state abilities in both deaf and hearing children rely to some extent on language. Even when they do not demand a verbal response (the child can answer by pointing to a given location), they still require that children possess sufficient linguistic skills to comprehend the story told by the experimenter and his or her subsequent questions. Poor comprehension of linguistic input, rather than a genuine theory of mind deficit, could therefore explain impaired task performance in mental state attribution tasks, as well as deaf children's poor performance in the Steeds et al. (1997) study (relative to how hearing children normally perform) not only on the test questions but also on the *control* questions of theory of mind tasks. The shorter developmental delay Steeds et al. reported, compared to that Peterson and Siegal (1995) reported, could be traced to the different linguistic demands that each study imposed on the children. Whereas Steeds et al. presented the changed location (Baron-Cohen et al., 1985) and deceptive box (Baron-Cohen, 1991) stories in children's preferred language (namely, British Sign Language), Peterson and Siegal (1995) told the stories in spoken language and then translated them into signed English, even though most children's preferred mode of communication was Auslan. Even *hearing* children's performance improves when linguistic demands are reduced, for instance, by making the pragmatic context of the testing situation clearer or by acting out the story narrated (Chandler, Fritz, & Hala, 1989; Freeman, Lewis, & Doherty, 1992).

Our aim in this study was thus to distinguish between two plausible interpretations of the existing pattern of findings: do deaf children born of hearing parents suffer from a *genuine* developmental delay in theory of mind acquisition, or is this just an *apparent* lag due to task-based comprehension problems that mask their underlying competence? To discriminate between these two hypotheses, we attempted to minimize the linguistic demands on the children through a nonverbal task of false-belief understanding. If deaf children do understand false beliefs, they should show no delay on such a nonverbal task. If, on the other hand, there is a genuine delay in their understanding of false belief, it should extend to such a nonverbal task.

The nonverbal task was adapted from Call and Tomasello (1999), who originally devised it to test chimpanzees' and orangutans' attributional skills. It consists of a hiding-finding game in which subjects can successfully choose the location of a reward that an experimenter (the "hider") has hidden in one of two identical opaque boxes only if they are able to interpret the nonverbal information provided by another experimenter (the "communicator") *in an appropriate way.* Subjects must be able to distinguish between those trials in which the communicator holds a true belief and points accurately at the box containing the reward and those in which she holds a false belief (because the locations of the loaded and the empty box were swapped in full view of the child but not of the communicator) and points inaccurately.

Two important modifications were made to the original task. First, whereas Call and Tomasello (1999) followed the standard procedure used in verbal false-belief tests, in which one of the characters leaves the room while a hidden object's location is changed by the other character, this study used blindfolding of the communicator as a signal of her inability to see what was happening. The reason for adopting this change was that, because the nonverbal task consisted of a *series* of control and false-belief test trials, the communicator would have to leave the room *repeatedly* and come back in. In a pilot study carried out before the actual experiment, this continual coming and going greatly distracted children's attention, yet throughout the game it is crucial that children closely follow what is happening if they are to choose the right box. Admittedly, changing the procedure in this way introduced the risk that children might find it strange that the communicator *willingly* covered her eyes. However, in the event, children readily accepted this manuever as part of the game played with the two experimenters.

The second innovation beyond Call and Tomasello's (1999) experimental design was the introduction of two false-belief trials in which the location of the hidden reward was *not* changed. If the location of the two identical containers had been always swapped in the false-belief trials, then children might have adopted (through trial and error learning across the various trials) a simple strategy allowing them to pick the correct box for the "wrong" reasons. Rather than making an inference based on the communicator's beliefs, they might have merely followed a rule based on her actions ("every time she covers her eyes, I should chose the box she does not point to"—this reasoning not implying an understanding of *why* this should be so). To avoid this false positive, we inserted two trials in which, in spite of covering her eyes, the communicator did point to the *correct* box, because its location had not been altered. This procedure helped to establish that children decided which box to choose by working out the relationship between what had *really* happened (change or no change of location) and what the communicator *thought* had happened (no change).

The last trial of the game was a verbal one, in which children *knew* where the reward was, but the communicator did not. Children were asked about the communicator's belief concerning the location of the reward. We predicted that, if children have problems only in understanding a verbally posed test, then their performance on the verbal trial should be worse than on the nonverbal trials.

Method

Participants

Twenty-four prelingually deaf children born of hearing parents participated. Three of them were eliminated from the data analysis because they did not pass the control tests (age range: 3 years and 5 months–7 years and 4 months; mean age: 5 years and 2 months).

We divided the remaining sample into two groups. The younger group included 11 children (7 boys, 4 girls) whose ages ranged from 4 years and 7 months to 6 years and 5 months (mean = 5 years and 6 months; *SD* = 6.9 months). The older group included 10 children (6 boys, 4 girls) whose ages ranged from 6 years and 9 months to 11 years and 11 months (mean = 9 years and 7 months; *SD* = 24.3 months).

The sample was drawn from different integration schools in Catalunya. All children came from middle- or upper-middle-class homes, except one child who came from a lower-middle-class home. All of them had been trained orally and spoken Catalan or Spanish was their preferred mode of communication. They all wore hearing aids; only one of them had had a cochlear implant. Five of the children were severely deaf (from 65 dB hearing loss in the better ear); the remaining 16 were profoundly deaf (over 90 dB hearing loss). None of the children had associated handicaps.

Procedure

Each child was placed in a room with two adults: the hider and the communicator. The hider and the child sat on opposite sides of a table, facing each other. The communicator sat on a chair beside the hider, so that she had a good view of the hider's actions, including those she performed on her lap.

Children were told in their preferred oral language (Catalan or Spanish) that they were going to play a hiding-finding game: when asked, they would need to answer where a sticker was located by pointing to one of two boxes; and they could keep the sticker every time they were correct. Stickers measured about 6×5 cm and represented different kinds of dinosaurs and jungle animals. The location of the sticker was randomized.

The experiment had five phases: pretest, controls, second pretest, nonverbal false-belief test, and verbal false-belief test.

Pretest. During this phase, children were familiarized with the game and discovered the role of the communicator.

The hider placed a sticker in one of two identical opaque boxes, manipulating them under the table so that children could not see. As the hider did so, the communicator overtly observed the process by leaning over the hider's shoulder and signed complicity to the children by smiling and winking. Both boxes were then replaced on the table and the communicator pointed to the one containing the sticker, making sure that children saw where she pointed. The hider encouraged children to choose one of the two boxes, by pushing the boxes forward within their reach and asking them orally: "Where is the sticker?"

Pretest trials were repeated three times. If children got the three of them correct by selecting the box indicated by the communicator, the next phase started. If they got fewer than two correct, they were eliminated from the study. If they were right on two out of three, they were given another pretest trial to confirm that they had a good understanding of the communicator's role and were included in the analysis only if they got this fourth trial correct.

Controls: The aim of the control trials was to test for two prerequisites necessary for successful performance in the next phase: first, children's ability to keep track of the sticker when the experimenter changed the location of the box in which they knew the sticker to be hidden (invisible displacement control) and second, the ability to ignore the communicator's signal when children knew it to be wrong (ignore communicator control).

Control test (a), the invisible displacement control, was run in the same way as the pretest trials, up to the point where the communicator had signaled one box. The communicator then put a scarf around her eyes, making it obvious that she could not see. The hider swapped the location of the two identical boxes on the table, in full view of the children. Upon a signal from the hider, the communicator uncovered her eyes. The hider encouraged the children to choose a box by pushing both boxes forward toward them.

Assuming children knew that when a container is displaced, so are its contents (stage 6 of object permanence), we believed they should choose the box that had been signaled by the communicator, even though it had changed location after the communicator's signal.

In control test (b), the ignore communicator control, the hider hid the sticker, manipulating the boxes under the table while the communicator observed the process. The communicator then covered her eyes. The hider opened the loaded box and moved the sticker into the other box, in full view of the children. Upon a signal from the hider, the communicator uncovered her eyes and pointed to the box at the location where she had seen the sticker being hidden (which was by now the incorrect box). The hider pushed the two boxes forward to let children pick one of them. Children were expected to ignore the communicator's signal, since they had seen where the sticker had been moved.

Each control test was administered twice, in the order a, b, a, b. If children failed both trials of either of the two control tests, they were eliminated from the study.

Second pretest. This was exactly like the pretest, except that it involved one rather than three trials. During the controls, children had had some experience of the communicator no longer being helpful (because she pointed at the wrong box). Therefore, they may now have been somewhat distrustful. The second pretest was intended to re-establish the communicator's reliability.

Nonverbal false-belief test (NVFB). Seven trials of the nonverbal false-belief test were given to each child. In five of them the location of the boxes was shifted; in the other two it was not, as described below:

1. NVFB with shift. The hider hid the sticker in view of the communicator and then placed the boxes on the table. As in control (b), the communicator then covered her eyes and the hider swapped the boxes while the communicator kept her eyes covered.[1] The communicator was then allowed to uncover her eyes. She then signaled by pointing to the box at the location where she had seen the sticker being hidden (that is, the wrong box). The hider pushed both boxes forward and asked children to choose.

The crucial difference between this test and control (b) is that children had not seen the sticker hidden: they did not know where it was. Therefore, they could not simply *ignore* the communicator: they needed to infer that the communicator was wrong (i.e., held a false belief, because she did not witness the change in the boxes' locations) and to choose the opposite box from the one that the communicator had signaled.

2. NVFB without shift. The procedure was the same as above, except that the hider did not move the boxes while the communicator kept her eyes covered. The no-shift trials were intermixed with the shift trials in a fixed order (shift, no-shift, shift, shift, no-shift, shift, shift).

Verbal false-belief test. This test was identical to control (b) (in which children saw the sticker being moved while the communicator had her eyes covered), except that, rather than being encouraged to choose a box themselves, children were asked about the box that the communicator would point to: "When X uncovers her eyes, which box will she point to?" If they did not answer, they were prompted by the question: "In which box does X *think* that the sticker is?"

Scoring

Children's responses were recorded in terms of which box they chose. On all occasions the correct choice was the one containing the sticker, except in the verbal false-belief task, when the correct choice was the empty box (recall that children were not asked about the location of the sticker, but about the communicator's belief).

Results

Nonverbal False-Belief Test

Group performance. Table 1 shows the number of younger and older children who scored 0, 1, 2, 3, 4, or 5 correct for the five trials of the nonverbal false-belief task with shift. Similarly, Table 2 shows the number of younger and older children who scored 0, 1, or 2 correct for the two trials of the nonverbal false-belief task without shift; and Table 3 shows the number of younger and older children who scored 0, 1, 2, 3, 4, 5, 6, or 7 correct on the nonverbal false-belief task as a whole.

Inspection of these tables suggests that the older group performed above chance whereas the younger group did not. One-sample Kolmogorov-Smirnov tests

Table 1 Number of younger and older children who scored 0, 1, 2, 3, 4, or 5 correct for the five trials of the nonverbal false-belief task with shift

	0	1	2	3	4	5	Mean correct trials
Younger (n = 11)	4	0	2	2	1	2	2.18
Older (n = 10)	0	0	1	2	1	6	4.20

Table 2 Number of younger and older children who scored 0, 1, or 2 correct for the two trials of the nonverbal false-belief task without shift

	0	1	2	Mean correct trials
Younger (n = 11)	1	3	7	1.54
Older (n = 10)	0	2	8	1.80

Table 3 Number of younger and older children who scored 0, 1, 2, 3, 4, 5, 6, or 7 correct on the nonverbal false-belief task as a whole

	0	1	2	3	4	5	6	7	Mean correct trials
Younger (n = 11)	0	1	4	0	2	2	0	2	3.73
Older (n = 10)	0	0	0	0	2	1	2	5	6.00

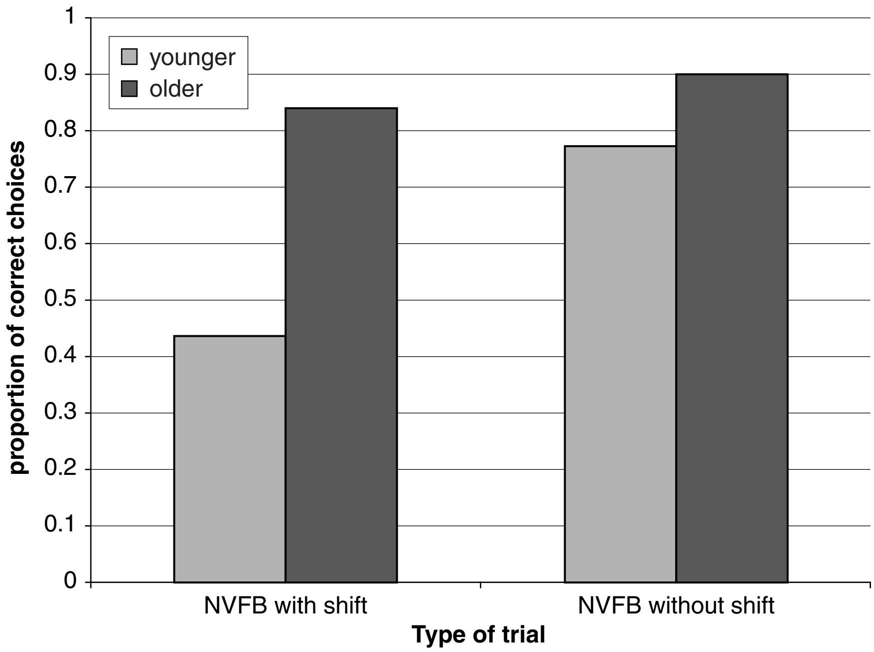

Figure 1 Proportion of correct choices in the NVFB with shift and NVFB without shift trials, for the older and younger groups.

(two-tailed) were carried out to determine whether children's performance on all three measures of the nonverbal false-belief test (NVFB with shift, NVFB without shift, and NVFB total) significantly departed from chance. Separate tests were carried out for the two age groups. The older group performed above chance on the NVFB with shift trials ($D[n = 10] = 0.569, p < .01$), on the NVFB without shift trials ($D[n = 0] = 0.55$, $p < .01$) and on the two sets of trials combined ($D[n = 10] = 0.635$, $p < .01$). By contrast, the younger age group did not perform above chance on any of the three measures, NVFB with shift ($D[n = 11] = 0.332$, ns), NVFB without shift ($D[n = 11] = 0.386$, ns), and NFVB total ($D[n = 11] = 0.228$, ns).

A two-factor mixed analysis of variance (ANOVA) was carried out to compare children's performance across age and type of trial. The between-subjects factor was age (younger vs. older); the within-subjects factor was type of trial (with shift vs. without shift). The dependent variable was the proportion of correct trials on each test.

The ANOVA confirmed that older children were more accurate than younger children, age $F(1, 19) = 7.596$, $p = .013$), and that children performed more accurately on the without shift task compared to the with shift task, type of task $F(1, 19) = 4.380$, $p = .05$). Although Figure 1 suggests the age difference was especially marked for the with shift task, the Age $\times$ Type of task interaction was not significant, $F(1, 19) = 2.13$, ns). Repeating this ANOVA with the proportional scores transformed using an arcsine transformation produced the same pattern of results.

Individual performance. The probability of choosing the correct box on all seven trials of the NVFB total test is .0078. The probability of choosing the correct box on at least six of seven trials is .06. This second criterion was taken as a legitimate cut-off point, because it is close to the normally accepted 5% level of statistical significance.

Two children in the younger group and six in the older group met this criterion. The youngest of these successful children was 5 years and 9 months. The mean age of the eight individually successful children was 8 years and 10 months.

Verbal tests. Table 4 shows the number of younger and older children who scored 0 or 1 correct on the verbal false-belief task.

One-sample Kolmogorov-Smirnov tests (two-tailed) were carried out to assess whether children's performance on the VFB task significantly departed from chance. Younger children performed significantly *worse* than chance ($D[n = 11] = 0.409$, $p = .05$). By contrast, older children's performance did not significantly depart from chance ($D[n = 10] = 0$, ns).

Table 4 Number of younger and older children who scored 0 or 1 correct on the verbal false-belief task

	0	1	Mean correct trials
Younger ($n = 11$)	10	1	0.09
Older ($n = 10$)	5	5	0.50

Comparison Between the Nonverbal and Verbal False-Belief Tests

Out of the seven trials of the nonverbal test, only the first (with-shift) trial was compared against the unique trial of the verbal test.[2] Nine children passed the first nonverbal trial while failing the verbal trial, whereas only one child failed the nonverbal while passing the verbal trial. Of the remaining 11 children, 6 failed on both trials and 5 passed both. A two-tailed McNemar's test with correction for continuity revealed that performance was significantly better in the first nonverbal with shift trial than in the verbal trial ($\chi^2 = 4.9, p < .05$).

Discussion

Two main findings of this experiment allow us to address the question initially raised: does deaf children's impaired performance in theory of mind tasks reflect a genuine developmental lag in their mental state attribution abilities, or is it merely an artefact of flawed assessment methods that rely too heavily on language comprehension?

On one hand, the suspicion that poor linguistic comprehension of standard, *verbally* presented false-belief tests may cause deaf children's poor performance was confirmed because, irrespective of age group, the nonverbal version of the task used in this experiment proved easier than the verbal version. We acknowledge, however, that this verbal/nonverbal discrepancy could have been a consequence of the methods the verbal test used. When posing the crucial question, the hider may not have succeeded in conveying that she was asking about the box that the communicator *would* choose, rather than about the box where the sticker really was. If children did not pay sufficient attention to the question, they might have persisted in their previous goal: to choose the loaded box. To keep an already lengthy procedure as short as seemed possible, we did not include control questions (e.g., "Where was the sticker in the beginning?" "Where is it now?") in the verbal task. With hindsight, such questions would have been illuminating, especially for those children who passed the nonverbal task *and* failed the verbal task. If deaf children's performance in standard tasks of false-belief understanding is hindered by their linguistic difficulties with the testing procedure (rather than by difficulties with mental representation per se), then we might expect that children who pass the nonverbal task but fail the verbal task would also have problems with the control questions of the verbal task.

In any case, the finding that children of all ages performed better in the nonverbal than in the verbal version of this task should not imply that impaired performance in false-belief tasks is *only* an artificial side effect of the testing procedure. Even though minimizing linguistic demands with a nonverbal test facilitated children's performance, the younger group in this experiment still performed worse than would have been expected for their mean chronological age (5½ years), although we emphasize that this expectation is based on the results of experimental designs in which standard, rather than nonverbal tasks, were used. Whereas most hearing children's performance in standard theory of mind tasks is accurate from 4 or 5 years (Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998), the mean age of successful deaf children in this experiment's nonverbal false-belief test was 8 years and 10 months. This figure represents a developmental delay in the emergence of false-belief attribution of about 4 years.

Prelingually deaf children born of hearing parents have limited access to language in their first years of life; thus, a developmental delay in their capacity to attribute false beliefs is consistent with the claim that conversational competence drives theory of mind development (Deleau, 1996; Harris 1996, 1999; Peterson & Siegal 1995, 1998, 1999, 2000). This hypothesis confirms the evidence that having older siblings facilitates theory of mind development in hearing children (Perner, Ruffman, & Leekam, 1994; Ruffman, Perner, Naito, Parkin, & Clements, 1998), inasmuch as older siblings increase opportunities for linguistic interchange (Brown, Donelan-McCall, & Dunn, 1996; Dunn, 1994).

This finding revealing a developmental delay in deaf children's acquisition of a theory of mind accords with findings of previous studies that have also detected such a delay (see Peterson and Siegal's [2000] review). However, the lag in this experiment is shorter than that reported in a number of these studies (e.g., Deleau, 1996; Peterson & Siegal, 1995, 1998, 1999; Russell et al., 1998; Steeds et al., 1997). This could reflect the fact that all the children in this sample were orally trained and wore hearing aids. Although in most cases this fact would not have ensured normal exposure to language from their very first year (because most children started wearing hearing aids only later on, and because hearing aids are not always helpful for children with a profound hearing loss), it probably did mean that some of the children were already benefiting from exposure to language during the preschool period. Arguably, this exposure accelerated their theory of mind development with respect to signing deaf children not wearing hearing aids.

In support of this hypothesis is Peterson and Siegal's (1999) finding that the performance of *oral,* first-generation deaf children on standard theory of mind tasks did not significantly differ from the performance of hearing children on the same tasks.[3] However, Courtin and Melot (1998) found that, among 7-year-old profoundly deaf children born of hearing parents, orally trained children performed *worse* in false-belief tasks than did sign-trained children,[4] and Courtin (2000) has likewise reported a slightly longer developmental delay in theory of mind acquisition among oral than among signing deaf children born of hearing parents. Thus, whether receiving an oral-based education positively affects first-generation deaf children's theory of mind development remains to be clarified.

Early deprivation of linguistic input among deaf children born of hearing parents will be mitigated gradually by increasing opportunities (as the children grow older and come in contact with native signers at school, or as they acquire spoken language if orally trained) for exposure to, and participation in, conversation. Thus, the conversational hypothesis predicts an influence of age on deaf children's theory of mind test performance. Indeed, we found such an influence in this study: although the younger group did not perform significantly above chance, the older group did. This finding contrasts with that of Peterson and Siegal (1995), who reported no relationship between age and test performance, but supports Peterson and Siegal (1999), who found a correlation between the two. Russell et al. (1998) also report an effect of age on test performance, although this effect was apparent only for their eldest group (13–16 years old). No performance differences separated their youngest and middle groups (the equivalent in age to this experiment's younger and older groups, respectively).

However, age is only a crude index of conversational competence: some of the deaf children born of hearing parents might belong to families providing a rich communicative milieu, in which attempts to engage in conversation with the deaf child are prioritized. This might hasten the young child's acquisition of mentalizing skills, and it could be one of the factors responsible for the large individual differences in theory of mind task performance among deaf children. For instance, the youngest individually successful child in our sample was 5 years and 9 months, whereas the oldest child who still failed the nonverbal test was 10 years and 11 months.

Further studies should thus be aimed at examining more precisely the degree to which conversational competence, rather than age, correlates with theory of mind task performance. The extent to which children initiate communication, ask questions, introduce new topics (rather than producing mere repetitions of other people's utterances), are interested in linguistic interchange, and follow a conversation, together with other pragmatic measures, would all be relevant indices of children's conversational competence and should be included in such studies.

A possible criticism that could be directed at this study concerns the replacement of a verbally presented task by a nonverbal task relying on pointing as a mode of communication. Autistic children who have difficulties in theory of mind tests also experience problems with the production and understanding of pointing as a communicative gesture to direct and share attention (Baron-Cohen, 1989b; Baron-Cohen, Allen, & Gillberg, 1992; Mundy, Sigman, & Kasari, 1994; Mundy, Sigman, Ungerer, & Sherman, 1986). Thus, our testing method might have posed particular obstacles to deaf children if they also have difficulties with understanding the function of pointing. However, no evidence suggests that they do. Indeed, it would seem reasonable to assume that deaf children born of hearing parents must be quite familiar with the use of pointing as a communicative device. Among normally hearing children, pointing is both produced and understood in the course of the second year (Carpenter, Nagell, & Tomasello, 1998). It would therefore provide a "natural" mode of communication between a deaf child and a (nonsigning) hearing parent.

The most important limitation of this experiment was the lack of a control group of hearing children of the same age range as the deaf children. On the basis of Call and Tomasello's (1999) finding that hearing children's cut-off age (4–5 years) for passing their nonverbal false-belief test was comparable to that found in most standard, verbal versions of false-belief tasks, we assumed that the nonverbal task used in our study could provide a legitimate means to assess deaf children's capacity to attribute false belief and to compare deaf children's mentalizing abilities with those of hearing children. However, there is some reason to doubt that, in the modified version of Call and Tomasello's (1999) task implemented here, the cut-off age for *hearing children* would have been exactly the same as it is in standard verbal tests. The changes introduced in this study were an attempt to reduce the chances of obtaining false positives, and precisely this might make the task harder for *all* (both deaf and hearing) children. Stated differently, hearing children's performance in Call and Tomasello's study might have been inflated by false-positive results: perhaps 5-year-olds' good performance on their test was due, at least in some cases, to children's discovery and application of a simple rule of thumb ("When the communicator leaves the room, choose the box she did not signal"). Eliminating the effectiveness of such a strategy (through the introduction of no-shift trials) would have removed false-positive cases, but it could also have resulted in increased task complexity.[5] Studies using a sample of hearing controls would be useful to elucidate this issue.

Further research should also investigate whether deaf children's developmental delay extends to all aspects of theory of mind, or whether it is confined to false-belief attribution. Among both children with autism (Baron-Cohen, 1991; Phillips, Baron-Cohen, & Rutter, 1995) and without autism (Wellman & Bartsch, 1994; Wellman & Woolley, 1990), researchers have found a lag between the understanding of volitional and epistemic mental states. Hence, it would be useful to design nonverbal tasks testing for deaf children's ability to understand volitional as opposed to epistemic mental states.

Notwithstanding these suggestions for further research, our findings point to an important interim conclusion. Even when test linguistic demands are minimized, and even when deaf children are called on to interpret a gesture likely to be highly familiar to them, they display difficulties in attributing a false belief until they are 8 to 9 years old. That is, false-belief understanding (as revealed by false-belief attribution tests) does not emerge among deaf children born of hearing parents until approximately 4 years later than it does among nonautistic, normally hearing children.

Notes

1. At this point, the children did not know where the sticker was, but if they passed control (a) (invisible displacement), they must have known that its location had been changed.

2. Choosing the first nonverbal trial for comparison with the single trial of the verbal test leaves no room for participants' performance in the nonverbal test to improve through trial-and-error learning across trials.

3. Although this seems to contradict this experiment's findings, inasmuch as Peterson and Siegal (1999) did *not* find a developmental delay in theory of mind acquisition for their group of oral deaf children, their oral deaf children were much older (mean age = 9 years and 2 months; range: 6 years and 10 months–13 years and 2 months) than our younger children (mean age = 5 years and 6 months; range: 4 years and 7 months to 6 years), who, as a group, failed the nonverbal task. Thus, a relatively short delay, as detected in this experiment, may have gone unnoticed in Peterson and Siegal's study because the oral deaf children in their sample were old enough to perform accurately.

4. Yet Courtin and Melot's (1998) finding could have been due to the fact that the orally trained children in their sample

had started to wear hearing aids relatively late: the authors do not report on the length of time and the degree to which orally trained children in their sample had benefited from hearing aids.

5. That it was appropriate to introduce no-shift trials is supported by the pattern of results obtained in our study: some of the children who chose the correct box on all of the with-shift trials nevertheless made a mistake on at least one of the no-shift trials. This indicates that they might have been following the simple strategy stated above, rather than choosing on the basis of mental state inferences.

Received September 11, 2000; revision received November 2, 2000; accepted November 5, 2000

References

Avis, J, & Harris, P. L. (1991). Belief-desire reasoning among Baka children: Evidence for a universal conception of mind. *Child Development, 62,* 460–467.

Baron-Cohen, S. (1989a). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30,* 285–298.

Baron-Cohen, S. (1989b). Perceptual role-taking and protodeclarative pointing in autism. *British Journal of Developmental Psychology*, 7, 113–27.

Baron-Cohen, S. (1991). Do people with autism understand what causes emotion? *Child Development, 62,* 385–395

Baron-Cohen, S. (1994). How to build a baby that can read minds: Cognitive mechanisms in mindreading. *Cahiers de psychologie cognitive/ Current psychology of cognitio*n, 13(5), 513–522.

Baron-Cohen, S. (1995). *Mindblindness. An essay on autism and theory of mind.* Cambridge, MA: MIT Press.

Baron-Cohen, S., Allen, J., & Gillberg, C. (1992). Can autism be detected at 18 months? The needle, the haystack and the CHAT. *British Journal of Psychiatry, 161,* 839–843.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21,* 37–46.

Brown, J. R., Donelan-McCall, N., & Dunn, J. (1996), Why talk about mental states? The significance of children's conversations with friends, siblings and mothers. *Child Development, 67,* 836–849.

Byrne, R., & Whiten, A. (1988). *Machiavellian intelligence: Social expertise and the evolution of intellect in monkeys, apes, and humans.* Oxford: Oxford University Press.

Call, J., & Tomasello, M. (1999). A nonverbal false belief task: The performance of children and great apes. *Child Development, 70*(2), 381–395.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development.* Serial number 255.

Chandler, M., Fritz, A. S., & Hala, S. (1989). Small-scale deceit: Deception as a marker of two-, three- and four-year-olds' early theories of mind. *Child Development, 60,* 1263–1277.

Courtin, C. (2000). The impact of sign language on the cognitive development of deaf children: The case of theories of mind. *Journal of Deaf Studies and Deaf Education, 5*(3), 266–276.

Courtin, C., & Melot, A. M. (1998), Development of theories of mind in deaf children. In M. Marscharck (Ed.), *Psychological perspectives on deafness* (pp. 79–102). Malwah, NJ: Erlbaum.

Deleau, M. (1996). L'attribution d'états mentaux chez des enfants sourds et entendants: Une approche du rôle de l'expérience langagière sur une théorie de l'esprit. *Bulletin de Psychologie, 50*(427), 48–56.

Dunn, J. (1994). Changing minds and changing relationships. In C. Lewis & P. Mitchell (Eds.), *Children's early understanding of mind* (pp. 297–310). East Sussex: Erlbaum.

Flavell, J. H., Flavell, E. R., & Green, F. L. (1983). Development of the appearance-reality distinction. *Cognitive Psychology, 15,* 95–120.

Fletcher, P., Happé, F., Frith, U., & Baker, C. S. (1995). Other minds in the brain: A functional imaging study of "theory of mind" in story comprehension. *Cognition, 57*(2), 109–128.

Freeman, N. H., Lewis, C., & Doherty, M. J. (1991). Preschooler's grasp of a desire for knowledge in a false-belief prediction: Practical intelligence and verbal report. *British Journal of Developmental Psychology, 9,* 139–157.

Frith, U. (1989). *Autism: Explaining the enigma*. Oxford: Basil Blackwell.

Happé, F. (1994). *Autism. An introduction to psychological theory.* London: UCL Press.

Happé, F., Ehlers, S., Fletcher, P., Frith, U., Johansson, M., Gillberg, C., Dolan, R., Frackowiak, R., & Frith, C. (1996). Theory of mind in the brain. Evidence from a PET scan study of Asperger syndrome. *Neuroreport, 8*(1), 197–201.

Harris, P. L. (1996). Desires, beliefs and language. In P. Carruthers & P. K. Smith (Eds.), *Theories of theories of mind* (pp. 344–354). Cambridge: Cambridge University Press.

Harris, P. L. (1999). Acquiring the art of conversation: Children's developing conception of their conversation partner. In M. Bennett (Ed.), *Developmental psychology: Achievements and prospects* (pp. 89–105). London: Psychology Press.

Humphrey, N. (1984). *Consciousness regained.* Oxford: Oxford University Press.

Jenkins, J. M., & Astington, J. W. (1996). Cognitive factors and family structure associated with theory of mind development in young children. *Developmental Psychology, 32,* 70–78.

Jenkins, J. M., & Astington, J. W. (1999). A longitudinal study of the relation between language and theory of mind development. *Developmental Psychology, 35*(2), 1311–1320.

Leekam, S. R., & Perner, J. (1991). Do autistic children have a metarepresentational deficit? *Cognition, 40,* 203–218.

Mundy, P., Sigman, M., & Kasari, C. (1994). Theory of mind and joint attention deficits in autism. In S. Baron-Cohen et al. (Eds.), *Understanding other minds: Perspectives from autism.* Oxford: Oxford University Press.

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits in autism: The contribution of nonverbal communication measures. *Journal of Child Pscyhology and Psychiatry and Allied Disciplines, 27,* 657–669.

Perner, J., Frith, U., Leslie, A. M., & Leekam, S. R. (1989). Exploration of the autistic child's theory of mind: Knowledge, belief and communication. *Child Development, 60,* 689–700.

Perner, J., Ruffman, T., & Leekam, S. R. (1994). Theory of mind is contagious: You catch it from your sibs. *Child Development, 65*(4), 1228–1238.

Peterson, C., & Siegal, M. (1995). Deafness, conversation and theory of mind. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 36*(3), 459–474.

Peterson, C., & Siegal, M. (1998). Changing focus on the representational mind: Deaf, autistic and normal children's concepts of false photos, false drawings and false beliefs. *British Journal of Developmental Psychology, 16*(3), 301–320.

Peterson, C., & Siegal, M. (1999). Representing inner worlds: Theory of mind in autistic, deaf and normal hearing children. *Psychological Science, 10*(2), 126–129.

Peterson, C., & Siegal, M. (2000). Insights into theory of mind from deafness and autism. *Mind and Language, 15*(1), 77–99.

Phillips, W., Baron-Cohen, S., & Rutter, M. (1995). To what extent can children with autism understand desire? *Development and Psychopathology, 7,* 151–169.

Ruffman, T., Perner, J., Naito, M., Parkin, L., & Clements, W. A. (1998). Older (but not younger) siblings facilitate false belief understanding. *Developmental Psychology, 34*(1), 161–174.

Russell, P. A., Hosie, J. A., Gray, C. D., Scott, C., Hunter, N., Banks, J. S., & Macaulay, M. C. (1998). The development of theory of mind in deaf children. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 39*(6), 903–910.

Rutter, M. (1991). Autsim as a genetic disorder. In P. McGuffin & R. Murray (Eds.), *The New Genetics of Mental Illness* (pp. 181–203). Oxford: Heineman Medical.

Segal, G. (1998). Representing representations. In P. Carruthers & J. Boucher (Eds.), *Language and thought: Interdisciplinary themes* (pp. 146–161). Cambridge: Cambridge University Press.

Smith, P. K. (1996). Language and the evolution of mindreading. In P. Carruthers & P. K. Smith (Eds.), *Theories of theories of mind* (pp. 344–354). Cambridge: Cambridge University Press.

Steeds, L., Rowe, K., & Dowker, A. (1997). Deaf children's understanding of beliefs and desires. *Journal of Deaf Studies and Deaf Education, 2*(3), 185–195.

Wellman, H. M., & Bartsch, K. (1994). Before belief: Children's early psychological theory. In C. Lewis & P. Mitchell (Eds.), *Children's early understanding of mind* (pp. 331–353). East Sussex: Erlbaum.

Wellman, H. M., & Wolley, J. D. (1990). From simple desires to ordinary beliefs: The early development of everyday psychology. *Cognition, 35*(3), 245–275.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13*(1), 103–128.

Yirmiya, N., Erel, O., Shaked, M., & Solomonica-Levi, D. (1998). Meta-analyses comparing theory of mind abilities of individuals with autism, individuals with mental retardation and normally developing individuals, *Psychological Bulletin, 124,* 283–307.