Research Report

REPRESENTING INNER WORLDS: Theory of Mind in Autistic, Deaf, and Normal Hearing Children

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Abstract—*The purpose of the study reported here was to examine the degree to which delays or deficits in developing a theory of mind are specific to children with autism or extend to other groups of atypical children with varying conversational experience and awareness. The performance of deaf children from a variety of conversational backgrounds was compared with that of autistic and normal hearing children on a range of tasks requiring representation of others' mental states. Native signers, oral deaf children, and normal hearing children scored similarly, and their performance exceeded that shown by signing deaf children from hearing families and children with autism. The latter two groups did not differ significantly from each other. These results point to an interplay among biology, conversation, and culture in the development of a theory of mind.*

The ability to represent mental states such as beliefs is central to human interaction (P.L. Harris, 1989; Wellman, 1990). Using tasks in which the purpose is to predict the behavioral consequences of protagonists' false beliefs, many studies have indicated that normally developing children acquire a rudimentary *theory of mind* by age 4, unlike children with autism. A number of discrete modular mechanisms have been postulated to account for the performance of normal children and children with autism (Baron-Cohen, 1992; Fodor, 1987; Frith, Morton, & Leslie, 1991; Premack, 1992). Although differing in detail, these nativist approaches share the view that neurobiological factors promote the growth of a theory of mind in normal children and create a deficit that may be unique to those with autism.

By contrast, cultural or environmental accounts (Lillard, 1997) ascribe the growth of concepts of mind to social interactions. By observing others and engaging in conversations, children come to construct representations of mental states. A growing number of studies support these accounts, showing that children's success on false-belief tasks depends on conversational experience and awareness (Siegal, 1997; Siegal & Peterson, 1994, 1996). For example, advanced understanding of false beliefs is found among preschoolers who frequently exchange mental-state terms in conversations with siblings and friends (Brown, Donelan-McCall, & Dunn, 1996; J. Dunn, 1994) and those regularly exposed to sophisticated speakers, including adults and older children (Lewis, Freeman, Kyriakidou, Maridaki-Kassotaki, & Berridge, 1996).

The abilities of deaf children to represent mental states may shed new light upon contrasts between neurobiological and cultural accounts. A child born profoundly deaf is likely to show many deviations from the normal developmental course of language and communication. One of these may involve the ability to conceptualize others' mental states. Until provided with access to conversation through sign language, many profoundly deaf children have no easy means of communication with hearing family members and other children. This is especially true for communicating about topics like mental states, which may have no obvious referent (Marschark, 1993; Meadow, 1975; Morford & Goldin-Meadow, 1997; Power & Carty, 1990).

There is evidence that selective deprivation of access to conversations about others' mental states delays deaf children's performance on theory-of-mind measures (Deleau, 1996; Guéhéneuc & Deleau, 1997; Peterson & Siegal, 1995, 1997, 1998). Signing deaf children of hearing parents are found to lag several years behind hearing children in their performance on false-belief tests, even when care has been taken to include only children of normal intelligence and social responsiveness in the deaf samples. Furthermore, the delay appears to apply to deaf children from hearing families rather than families in which sign is the native language, and to apply specifically to concepts of mind, rather than to a notion of representation more generally. For example, we (Peterson & Siegal, 1998) found that, during middle childhood, deaf children displayed a poor grasp of false belief yet succeeded readily on procedurally identical tasks requiring an understanding of false photographic representation. The performance of signing deaf children from hearing families was very similar to that of autistic children of equivalent nonverbal mental age on false-belief and false-photograph tasks.

Previous research is limited by the use of small samples of deaf children, who were often given a single false-belief task and whose performance was not compared with that of other groups of atypical children. The purpose of the present study was to provide a direct comparison of the performance of deaf children from a variety of conversational backgrounds with autistic and normal hearing children on a range of tasks requiring representation of others' mental states. We investigated understanding of false belief in three groups of deaf children: those from hearing families, those from families including a native speaker of sign language (e.g., a signing deaf parent, grandparent, or older sibling), and oral children equipped with hearing aids.

METHOD

Participants

After we excluded 6 children who failed control questions (3 normal preschoolers, 2 autistic children, and 1 deaf child), the sample consisted of 102 Australian children. The 59 deaf children had a mean chronological age of 9 years, 5 months (range: 5 years, 6 months–13 years, 2 months) and were students at Total Communication Units attached to government primary schools. The 21 normal 4-year-olds had a mean age of 4 years, 6 months (range: 3 years, 11 months–5 years, 4 months) and came from middle-class suburban preschools. The 22 autistic children had a mean age of 9 years, 6 months (range: 6 years, 2 months–13 years, 9 months). They had been diagnosed according to criteria in the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 1994) and were attending a special school for autism. Mean verbal mental ages were 8

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years, 4 months (range 3 years, 11 months–15 years, 4 months) for autistic children[1] and 4 years, 10 months (range 3 years, 5 months–9 years, 5 months) for normal preschoolers on the Peabody Picture Vocabulary Test (PPVT, L M Dunn & Dunn, 1981)

The deaf children were divided into three groups based on their communication backgrounds and modality To cater to both signing and speaking-listening (oral) deaf children, Total Communication Units used a simultaneous combination of spoken and signed English as the medium of instruction Group 1 consisted of 34 severely and profoundly deaf signers from hearing families These children ranged in age from 5 years, 6 months to 12 years, 8 months, with a mean of 9 years, 4 months Until entering a Total Communication Unit, none of these children had daily conversational access to anyone who used sign language as fluently as a native speaker The 11 severely and profoundly deaf children in Group 2 had a mean age of 10 years, 3 months (range 6 years, 6 months–12 years, 8 months) and were native signers At least one deaf native speaker of sign language was present in the household of each of these children so they resembled normal hearing children in that they had access even before school entry to a fluent conversational partner Like all the members of Group 1, they were adept in some form of signing (e g , Auslan or signed English) and used this as their predominant mode of discourse both inside and outside the classroom Group 3 consisted of 14 oral deaf children with a moderate to severe hearing loss and a mean age of 9 years, 2 months (range 6 years, 10 months–13 years, 2 months) Children in this group had grown up with spoken language input With the assistance of amplifying hearing aids that they had worn since infancy, these children had acquired speaking and listening skills in oral-aural language

Classroom teachers expertly detailed knowledge of these children's language skills,[2] in conjunction with the absence of any standardized PPVT equivalent for Australian deaf children led to our choice of teachers' ratings as the index of verbal ability for the deaf sample, as is common in research with deaf children (Marschark 1993) Teachers rated each child on scales of expressive language skill, comprehension, and vocabulary size, first in sign and then in speech Scores on the six resulting scales could range from a high of 5 (both "highly competent" and "well above the average for signing [oral deaf] children the same age"), through 3 ("average") to 1 (both "below average" and "inadequate for effective communication") The total sign score (created by averaging the three sign scales) had adequate internal consistency (Cronbach alpha = 94) as did the corresponding score for oral language ability With one exception (described later), children earned higher means in the modality their teachers had described as their preferred communication medium[3] Therefore, in statistical analyses involving verbal ability, we used the combined score from this better modality as the most accurate overall index of each child's receptive and expressive language skill The means for overall verbal ability were 3 27, 3 75, and 4 15 for the three deaf groups, respectively These means were not significantly different, $F(2, 56) = 2\ 87$, $p > 05$ Nor did the groups differ in mean age, $F(2, 56) = 1\ 15$, $p > 25$, ratio of males to females, $\chi^2(2, N = 59) = 3\ 48$, $p > 10$, or mean nonverbal IQ score as measured by the Goodenough-Harris Drawing Test (D B Harris, 1963), $F < 1$ Mean scores on the latter measure were 94 83, 101 71 and 101 00, respectively

1 To ensure task comprehension, we decided on a minimum verbal mental age of 3 years 11 months for the autistic children (Baron-Cohen 1992)

2 Classroom teachers had worked with these children intensively in classrooms of no more than five pupils throughout at least one academic year and in most cases ever since the child's first exposure to sign language

3 Deaf children were required to earn teachers ratings of at least 2 (below average but adequate) on all three scales in their better modality (speech or sign)

Procedure

A highly experienced professional sign language interpreter assisted the experimenter in testing the signing children by using each child's preferred sign language to translate all tasks and questions The experimenter dismissed the interpreter for children identified by teachers as oral With one exception, teachers' impressions were confirmed by these children's ability to cope with the tasks exclusively through speech The exception was a child whose speech and sign fluency scores were equal She signed that she needed an interpreter during the oral presentation of the first task Her request was granted, but she was included in Group 1 for all data analyses Three standard false-belief tests were individually presented in randomized order

Changed-location task

The Sally-Ann test (Baron-Cohen, Leslie, & Frith, 1985) was used exactly as described by the original authors except that a boy was substituted for "Ann" (see Peterson & Siegal 1995, 1997, for a rationale) Two trials each began with the girl hiding a marble in a basket and departing In her absence, the boy shifted the marble to a box (Trial 1) or the experimenter s pocket (Trial 2) The girl returned A belief test question was presented ("Where will the girl look for her marble?"), followed by two control questions ("Where is the marble now?" and "Where did the girl put the marble in the beginning?") Half the deaf children in each of the three groups received a conversationally modified "look first" question wording on both trials (Siegal & Beattie, 1991) However, as preliminary analyses revealed no significant effect of this manipulation on any group, data from both types of questioning were combined To pass the task children were required to respond correctly to both test questions and all four control questions

Changed-appearance task

For this task, we used a modification (Peterson & Siegal, 1998) of a procedure developed by Leekam and Perner (1991) The task began with a mother doll exclaiming to a girl doll "Oh, look at your pretty yellow dress! I will go and get some hair ribbons the same color as your dress!" The mother disappeared, the girl changed dresses, and the children were asked "Which of these ribbons did Mum bring?" (test question), "When Mum left, what color was the girl's dress?" (memory control), and "Now what color is her dress?" (reality control) A pass required correct responses to all three questions

Misleading-container task

The standard Smarties task described by Perner, Frith, Leslie, and Leekam (1989) was slightly simplified to reduce repeats of prompt and control questions The task involved a misleadingly familiar sweets container that actually held pencils After discovering the unexpected contents, subjects were asked what a naive classmate of the same status as themselves (e g , signing or oral) would say on first seeing the closed container and what their own initial belief had been Correct response to both these test questions was required for a pass, reducing the odds of chance success to 25%

Table 1 *Percentages of the children in each group who passed the three false-belief tasks*

Group	Task: Changed location	Task: Changed appearance	Task: Misleading container
Group 2 Native signers (n = 11)	82 (n = 9)	100 (n = 11)	91 (n = 10)
Group 3 Oral deaf (n = 14)	64 (n = 9)	71 (n = 10)	86 (n = 12)
Group 1 Signing deaf from hearing homes (n = 34)	38 (n = 13)	59 (n = 20)	47 (n = 16)
Autistic children (n = 22)	50 (n = 11)	68 (n = 15)	50 (n = 11)
Normal preschoolers (n = 21)	86 (n = 18)	90 (n = 19)	76 (n = 16)

RESULTS

Table 1 shows the percentage of children in each group who passed each false-belief task A one-way analysis of variance on the number of tasks passed revealed a statistically significant difference among groups, $F(4, 97) = 7\ 60$, $p < 001$ With respective means of 1 44 and 1 59 out of a maximum of 3, the signing deaf children in Group 1 did not differ significantly from the autistic children according to a Newman-Keuls test ($p < 05$) But they passed significantly fewer false-belief tasks than the native signers ($M = 2\ 73$), the oral deaf ($M = 2\ 21$), and the normal preschoolers ($M = 2\ 52$) There were no significant differences among the latter three groups (Newman-Keuls, $p < 05$)

Similar patterns of success and failure emerged on the individual tasks Pass rates by Group 1 children and autistic children did not differ significantly on the changed-location, changed-appearance, or misleading-container task Nor did success of native signers, oral deaf children, and normal preschoolers differ on any of these tasks But when results for the three latter groups were combined and contrasted with those for the two former groups, a significant difference emerged on each task changed location, $\chi^2(1, N = 102) = 12\ 85$, $p < 01$, changed appearance, $\chi^2(1, N = 102) = 9\ 73$, $p < 01$ and misleading container, $\chi^2(1, N = 102) = 12\ 93$, $p < 01$, all ps two-tailed Thus, patterns of success for individual tasks were consistent with those for total tasks passed Signing children from hearing households performed no better than autistic children, and displayed a poorer understanding of false belief than their signing or oral deaf peers who had fluent conversational partners at home

There were significant correlations between verbal ability and successful performance of the three false-belief tasks for Groups 1 and 3 and the autistic children (the latter using PPVT scores), r = 61, 68, and 77, all ps < 01, two-tailed Correlations were positive, but not significant, for native signers and normal preschoolers To test whether the differences between groups in success on the false-belief tasks would persist once verbal ability was partialed out, we performed two analyses of covariance The first, involving the deaf sample only, used teachers' ratings of verbal ability as the covariate The group effect on total tasks passed remained significant, $F(2, 56) = 3\ 90$, $p < 05$, and a planned comparison on the adjusted means indicated that children in Group 1 passed fewer false-belief tasks than those in Groups 2 and 3 even after adjustment was made for differences in verbal ability, $F(1, 56) = 4\ 30$, $p < 05$ Similarly, when the autistic and normal groups' PPVT scores were placed on a common metric with teachers' ratings of deaf children,[4] the analysis of covariance was significant, $F(4, 96) = 9\ 78$, $p < 001$, and planned comparisons again revealed better performance by Groups 2 and 3 and normal preschoolers than by the Group 1 and autistic children, even after adjusting for verbal ability

Chronological age was positively correlated with successful performance on the false-belief tasks in Group 1, $r(32) = 48$, $p < 02$, suggesting their difficulties may be conceptualized as a delay rather than a permanent deficit in development There was no significant correlation with chronological age among native signers or oral deaf children probably owing to the ceiling effects imposed by their near-perfect false-belief performance This result would be expected had they acquired a theory of mind, like normal preschoolers, around the age of 4 years

DISCUSSION

In line with Meadow, Greenberg, Erting, and Carmichael's (1981) observation that deaf preschoolers with deaf parents converse about nonpresent ideas, objects, and events as fluently in sign as do hearing children with hearing parents in speech, deaf children who had fluent conversational partners available at home during the preschool years performed as well as hearing children The fact that oral deaf children who used speech with their hearing family members did not differ significantly in false-belief performance from native signers who had a fluent signer at home suggests that the modality of spontaneous conversation makes little difference to the developmental outcome

The comparably poor performance by signing deaf children from hearing families and by autistic children can be interpreted in several ways Autistic children may have specific neurological damage that detracts from their capacity to represent mental states while at the same time producing other triadic impairments in language, imagination, and social functioning that culminate in a diagnosis of autism (Frith et al , 1991) There may also be a neurobiological basis for the performance of deaf children in that those from hearing homes who have been restricted in early conversational exposure have been observed in adulthood to display patterns of language-related brain activity that differ from patterns observed in both hearing adults and deaf native

4 As an approximation to the scale the teachers had used, PPVT standard scores within 1 standard deviation of the norm were scored 3, those 1 to 2 standard deviations above (or below) the mean were scored as 4 (or 2) and so on

signers (Marschark, 1993, Neville et al, 1997) Further research using brain-imaging techniques such as those employed by Fletcher et al (1995) is needed to determine the role of neurobiological factors in accounting for the similarities between autistic and deaf children

At the same time, however, it may be that conversational difficulties comparable to those that limit development of a theory of mind among profoundly deaf children in hearing families also block autistic children's opportunities to talk about, and appreciate, the mental states of others In comparing spontaneous mother-child dialogues over a 2-year period in households where the child had either autism or Down syndrome, Tager-Flusberg (1993) noted fewer references to mental states and appeals for joint attention in the dialogues with autistic children, despite comparable levels of talk about topics outside the cognitive domain Unlike their peers with Down syndrome, autistic children almost never spoke about mental states and never discussed cognitions in relation to behavior or in contrast with reality A selective inability to discuss mental states may flow from autistic children's failure to acquire normal conversational skills, in line with previous observations of their pragmatic language deficits and their limited social capacity to sustain dialogue (Bruner & Feldman, 1993) Consequently, autistic children may miss out on the kinds of dialogues that yield insight into the workings of their conversational partners minds Of course, deaf and autistic children may also have equivalent problems with representation of mental states for different reasons

A conversational account attributing deaf children's delayed understanding to a lack of discourse about invisible beliefs in households where no one else is fluent enough in sign language to spontaneously reveal the inner contents of their minds is in line with Lillard's (1997) notion that children entertain a wide variety of explanations for human behavior initially, narrowing these down to a mentalistic source only if they happen to grow up in a culture where psychological attributions are employed consistently by their conversational partners Of course, biological and cultural explanations need not be mutually exclusive It may also be that a critical level of conversational input about mental states is necessary to trigger neurological development Whatever the interpretation, our results underscore the likely role of early dialogue in developing a theory of mind and highlight the need for further research to clarify the degree to which representations of mental states are influenced by biological or cultural factors in conjunction with children's conversational background and awareness

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