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Drawing Insight from Pictures: The Development of Concepts of False Drawing and False Belief in Children with Deafness, Normal Hearing, and Autism

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Theory-of-mind concepts in children with deafness, autism, and normal development ($N = 154$) were examined in three experiments using a set of standard inferential false-belief tasks and matched sets of tasks involving false drawings. Results of all three experiments replicated previously published findings by showing that primary school children with deafness or autism, aged 6 to 13 years, scored significantly lower than normal-developing 4-year-old preschoolers on standard misleading-container and unseen-change tests of false-belief understanding. Furthermore, deaf and autistic children generally scored higher on drawing-based tests than on corresponding standard tests and, on the most challenging of the false-drawing tests in Experiment 2, they significantly outperformed the normal-developing preschoolers by clearly understanding their own false intentions and another person's false beliefs about an actively misleading drawing. In Experiment 3, preschoolers outperformed older deaf and autistic children on standard tasks, but did less well on a task that required the drawing of a false belief. Methodological factors could not fully explain the findings, but early social and conversational experiences in the family were deemed likely contributors.

INTRODUCTION

The ability to infer mental states such as intentions, memories, and true or false beliefs and to use these inferences to understand and predict the behavior of self and others is "one of the quintessential abilities that makes us human" (Baron-Cohen, 2000, p. 3). Known as a "theory of mind" (ToM), this capacity is often assessed using standard false-belief tasks that require children to infer what protagonists will do, say, or think in situations designed to create beliefs that are discrepant from reality (Astington, 2001; Dennett, 1979). A large body of research over the past 15 years has shown that most normal-developing 3-year-olds fail these tests, whereas most normal-developing 5-year-olds pass them (Flavell, 1999; Wellman, 1993; Wellman, Cross, & Watson, 2001). However failure persists, despite adequate language skills, in many older children with autism (Baron-Cohen, 2000; Baron-Cohen, Leslie, & Frith, 1985), deafness (Peterson & Siegal, 1995, 1999, 2000), or blindness (McAlpine & Moore, 1995; Minter, Hobson, & Bishop, 1998; Peterson, Peterson, & Webb, 2000), who may not show any clear evidence of understanding false belief until preadolescence or even later.

Indeed, from a review of 28 separate studies of inferential false-belief performance conducted over more than a decade in several different countries, Happe (1995) documented the severity of the false-belief deficit in children and adolescents with autism. Collectively sampling more than 300 autistic participants (all with mean verbal mental ages of 5 years and over), these studies consistently revealed higher failure rates on false-belief tasks than were seen in normal-developing children of similar verbal and nonverbal mental ages. For example, pass rates for autistic participants in 14 studies conducted from 1985 to 1993 with samples predominantly in their teens ranged from only 15% to 60%, with a mean of just 33% passing. Similarly, Yirmiya, Erel, Shaked, and Solomonica-Levi (1998) conducted a meta-analysis that confirmed that individuals with autism perform significantly less well than do individuals with normal development across a range of different ToM tests. Significant deficits were also found in individuals with mental retardation, relative to normal controls, albeit of a less severe nature than those linked with autism, prompting the conclusion that "ToM deficits can no longer be conceptualized as a core deficit that is unique to autism" (Yirmiya et al., p. 302).

Peterson and Siegal (2000) similarly reviewed the results of 11 separate studies, published between 1995 and 1999, of false-belief understanding in signing profoundly deaf children. Taken collectively, the populations of severely and profoundly deaf children tested in these studies were impressively varied, having been drawn from a wide variety of family circumstances, preferred communication modalities, sign language communities, and approaches to deaf education in several different countries. Yet the results

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were consistent in revealing substantial delays in false-belief understanding among the vast majority of late-signing deaf children who had grown up in hearing families, despite these children's normal intelligence, social responsiveness, and freedom from other clinical impairments bound up with a diagnosis of autism. deVilliers and deVilliers (1999) tested a group of orally trained deaf children who had severe prelingual hearing losses but were fitted with hearing aids that enabled the use of lip reading and amplified speech as their mode of communication. In spite of normal levels of nonverbal intelligence and social adjustment, these oral deaf children, like the late signers, were delayed an average of 3 years behind hearing children with regard to their performance on both verbal and nonverbal tests of false-belief understanding.

However, it seems that these observed delays are a consequence not of deafness per se, but rather of deafness in conjunction with a hearing family situation that curtails the normal flow of conversation. Profoundly deaf offspring of signing deaf parents (second-generation deaf signers), along with those who have access at home to other native speakers of sign language (e.g., a signing deaf grandparent or older sibling) can be dubbed "native signers" owing to the possibility, throughout their developing years, of conversing in sign language with fluently signing partners who share a common first language, such as American Sign Language (ASL) or Australian Sign Language (Auslan). On standard false-belief tests, native signers consistently outperform late-signing deaf children from hearing families (Peterson & Siegal, 1999, 2000) and may even achieve an understanding of false belief slightly sooner than do children of normal hearing from hearing-speaking families (Courtin & Melot, 1998).

When a child is born deaf into a hearing family (as are the vast majority of severely and profoundly deaf children born today; Marschark, 1993), there are likely to be many deviations from the normal developmental courses of language, communication, and socialization. One of these can involve the ability to conceptualize others' mental states. Many children with serious hearing impairments have no easy means of communication with parents and siblings (who rarely master sign language to the same level of fluency as a native speaker) about situations that cannot be seen or pointed at (Meadow, 1975). It is therefore unusually difficult for them to engage in family conversations about false or imaginary mental states that have no visible referent (Vaccari & Marschark, 1997), so that they are unlikely to have as much opportunity as do hearing children to engage in pretend play; to converse about feelings, intentions, mistakes, and memories; or to negotiate conflicts in a manner that flourishes in hearing families just before preschoolers begin to pass standard false-belief tasks (Brown, Donelan-McCall, & Dunn, 1996; Dunn, 1994).

Native signers, on the other hand, will have had at least one other person at home with whom to engage in these kinds of conversations. Consequently, the observed contrast between these children's evidently normal rate of acquisition of ToM and the severe delays observed among their late-signing deaf peers may reflect the family social environment and the extent to which the path is open for "language, and more generally participation in conversation [to] provide[s] a royal road to an understanding of one's own mental life and that of other people" (Harris & Leevers, 2000, p. 197).

Autism is diagnosed when children exhibit a characteristic triad of symptoms: (1) impaired language and communication, (2) social aloofness, and (3) impairments in imagination and flexibility of thinking (Frith, 1989). These symptoms enable a clinician to diagnose autism but are not deemed to be the root cause for the disorder and, although genetic dispositions and neurological brain abnormalities are implicated, "autism has defied all simple explanations" (Happe, 2000, p. 203). A number of neurobiological hypotheses both about core impairment causing autism and its possible connections with these children's delayed development of ToM have been proposed (e.g., Baron-Cohen, 1995; Frith, Morton, & Leslie, 1991; Leslie & Thaiss, 1992). Although differing in detail, these theories share the view that "in the normally developing child the computational capacity to represent mental states has an innate neurological basis. In the autistic child, neurological damage to a circumscribed system of the brain has occurred" (Leslie & Thaiss, p. 110).

However, an innately damaged ToM module is not the only possible explanation for the difficulties that children with autism encounter on tests of false belief. Executive functioning deficits (Bishop, 1993), weak central coherence (Happe, 2000), lack of social and affective engagement with others (Hobson, 1991), and core deficits for narrative encoding (Bruner & Feldman, 1993) have all plausibly been proposed. Furthermore, even accepting that autism itself is a congenital neurobiological disorder, this does not necessarily imply that associated ToM problems are either innate or purely neurobiological.

Tager-Flusberg's (1993) naturalistic observations in the homes of children with autism or with mental retardation intriguingly revealed significantly fewer conversational references to beliefs and other mental states in family dialogues that involved an autistic child. Although a modular neurobiological account might explain the lack of mentalistic conversation as an outcome of an innate ToM deficit in autism, it is conceivable that delayed false-belief understanding might be a consequence, rather than a cause, of the autistic child's selective deprivation of mental state conversation, in line with suggestions that normally developing preschoolers acquire a ToM through social and conversational experience (Garfield, Peterson, & Perry, 2001).

Indeed, individual differences among normal developers in false-belief understanding are found to parallel their range and depth of access to social experiences for play and conversation with parents, siblings, and peers (Astington, 2001), and ease of access to early family conversation likewise appears to be a predictor of ToM for deaf children. Experiential factors could conceivably also be relevant to ToM development in children with autism. However, it is equally conceivable that the causes for advanced, or delayed, false-belief understanding could differ for children in different diagnostic categories, and it is beyond the scope of the studies reported here to settle broad questions of directional causality.

Nevertheless, it may be useful to speculate on how different kinds of social experiences in the family, outside the realm of spoken conversations about beliefs, could conceivably open windows into others' minds. If input from the social environment is indeed relevant, at least for some children some of the time, it is important to consider routes that might still be open to a child with deafness in a hearing family, or to a child with autism who, although for different etiological reasons, is unlikely to converse with family members about cognitive mental states (Tager-Flusberg, 1993).

Could these children, in spite of their sensory or developmental disabilities and their unique situations with regard to family conversation, still manage to have access to some kinds of representational activities that might give them opportunities to learn about certain kinds of representational thought through a medium other than the language of propositional attitudes? When they draw pictures, doodle while speaking on the phone, or sketch a simple map or diagram, children and adults create public, tangible, nonverbal records that could prove suggestive about what is going on in their minds. Sometimes drawings may also be mistaken or may distort reality (as when a child draws a man that an observer recognizes as a lollypop). Furthermore, drawing and picture recognition are familiar aspects of social life at home and at school for deaf children (who are seen to develop picture-making skills at normal, or even advanced, rates relative to hearing peers; Marschark, 1993), and also for children with autism, who likewise pass through the stages of representational drawing development at typical ages, even when they do not possess the special skills of artistic savants (Charman & Baron-Cohen, 1993).

In other words, given that there are likely to be many opportunities during everyday life for children with deafness and with autism both to draw and to engage with others in conversations about drawings, might these children access these experiences in ways that would enable them to glean something about the process of representation, perhaps mental as well as physical? If so, might an early understanding of pictorial representation by drawing be recruited by children with deafness or autism to provide a beginning avenue into a ToM, even in the face of otherwise restricted exposure to discourse about abstract mental states such as false beliefs? In line with these possibilities, the present experiments aimed to explore children's understanding of drawings (1) as representations, (2) as the subject matter for beliefs and (3) as a medium for recording and expressing mental states.

EXPERIMENT 1

Studies suggest an earlier understanding of false photographic than false mental representation in children with autism (Leekam & Perner, 1991; Leslie & Thaiss, 1992), as well as in late-signing (Peterson & Siegal, 1998), and orally trained (deVilliers & deVilliers, 1999) deaf children. Specifically, children in these groups have all been found to score significantly higher on false-photo tests (requiring awareness that photographic representations do not automatically update themselves when scenes change) than on counterpart false-belief tests. A mature grasp of other people's visual perspectives is often evident in autistic adolescents and adults who fail corresponding tests of false belief (Reed & Peterson, 1990).

The results of two recent training studies (McGregor, Whiten, & Blackburn, 1998; Swettenham, Baron-Cohen, Gomez, & Walsh, 1996) are also pertinent to the possibility that pictures might open routes to an awareness of mental states in children with autism. In both studies, children who had autism were post-tested on standard false-belief tasks after having been coached on modified tasks in which they could use photographs as analogies for beliefs (e.g., by being taught to insert a picture representing a belief into the head of a doll protagonist). Both studies showed promising evidence that such training had proved beneficial. Furthermore, the children with autism seemed to profit only from pictorial training, rather than from other kinds of training such as verbally highlighting protagonists' intentions. However, their generalization of the training to new kinds of false-belief tasks was of limited scope.

Children's understanding of obsolete drawings has also been investigated along similar lines to the false-photo testing procedure used by Leekam and Perner (1991) and others in the studies cited above. Charman and Baron-Cohen (1992) constructed a task in which autistic children either drew a picture or watched an experimenter do so, and then witnessed a transformation of the scene that had been drawn. They were significantly better at predicting that the face-down drawing would not have altered to match present reality than they were at passing a standard false-belief task that required a similar understanding of the obsolete beliefs of a story protagonist who had not seen her toy being moved. Using a similar procedure, Slaughter (1998) found that the same was true of normal-developing 3-year-olds.

In each of these tasks, children had viewed the completed drawing before the scene was transformed, so that there was a possibility that the test question could have been answered via simple memory for the physical object (i.e., the drawing) that they had already looked at. Peterson and Siegal (1998) overcame this possibility by developing a version of the false-drawing task that more closely mirrored the standard false-photo procedure and precluded participants from simply reporting a memory. Children with deafness performed similarly to those with autism. More children in each of these groups (62% and 71%, respectively) passed the false-drawing task than a matching false-belief task (54% and 62%, respectively), although the differences were not statistically significant for either group. However, it was possible that some of the children may have failed the drawing tasks because of an ambiguity about the protagonist's goal. Experiment 1 addressed this potential methodological limitation, while also supplying a further test of the difficulty of false drawings relative to false beliefs for deaf and hearing children.

Method

Participants

The sample consisted of 46 Australian children: 21 signing deaf children and 25 normal-hearing preschoolers. The 10 deaf boys and 11 deaf girls ranged in age from 6 years, 8 months to 12,6 ($M = 9,3$ years) and were selected because they met all of the following criteria: (1) the children used sign language (signed English and/or Auslan) as their predominant and preferred communication medium according to both teachers' reports and direct observation during the testing session, (2) the children had attended a Total Communication (sign-plus-speech) primary school for at least 6 months and were rated by teachers as skilled enough in sign language to comprehend task instructions (a prediction that was confirmed by all children's satisfactory performance on control questions), (3) the children were severely or profoundly deaf and had become so prior to the acquisition of language, (4) neither of the children's parents were deaf or a native speaker of sign language, (5) the children had no serious known handicaps apart from deafness (e.g., autism, mental retardation, visual impairment, or cerebral palsy), (6) the children had not been included in previous ToM research, and (7) written parental permission to participate had been granted.

For comparison, as in much previous ToM research with deaf children, a group of normal-hearing 4-year-olds was included because their typically high rates of false-belief performance can provide a stronger indication of delays in the deaf sample than would be evident through the use of chronologically age-matched controls. These 25 children were attending suburban preschools; had English as their first language; and had no known or suspected sensory, cognitive, or other handicaps according to teachers' reports. There were 11 boys and 14 girls in the preschool group, with a mean age of 4 years, 9 months (*range* = 4,1 – 5,8).

Procedure

Each child was tested individually. For the signing deaf children, two adults were present, one male and one female. The latter was a professionally trained Auslan interpreter who was highly familiar with the style of Total Communication used in each deaf child's classroom, as well as with each child's own particular language preference (e.g., for signed English versus Auslan). The interpreter, who was seated beside the male experimenter (E) and directly opposite and in full view of the participant, simultaneously translated E's spoken narrative and questions into each child's preferred mode of sign language, using a style of interpretation that was highly familiar to these children. The narrators both paused while critical bits of the story were acted out by E (such as the doll's change of dress) and monitored that the child's gaze was directed at the props or the interpreter, as appropriate, before continuing each part of the procedure. Both adults independently recorded the child's pointing responses, and subsequent matching of their records revealed complete agreement. In addition, the interpreter supplied an ongoing oral translation of all the child's signed commentary for recording by *E* on the data sheets.

Tasks and Scoring

The following tasks were individually administered in a randomly assigned order.

Mental representation: Ribbons. Adapted from Peterson and Siegal (1998), this puppet-play task used a mother doll and a smaller girl doll in a brightly colored dress. *E* said: "Here is Mum. Here is the girl. See the girl's dress? What color is it? That's right, it's red [colors were varied randomly across participants]. Mum sees the girl in her red dress. She says: 'Oh, look at your pretty red dress! I'll go get you some hair ribbons the same color as your dress.' Mum goes away to get the ribbons [hide doll]. She can't see the girl. The girl goes into her room and changes her dress." *E* allowed the child to peek into the room and see the girl in a dress of a new color (e.g., yellow).

To enable pointing responses to the test questions, matched pairs of red, yellow, and blue (a novel color) ribbon were provided. Swatches of the three dress fabrics were similarly available for pointing responses to control questions. The false-belief test question: "Which ribbons does Mum bring?" was followed by comprehension control questions: "What color is the dress now?" and "What color dress did Mum see?" Any child who failed a control question would have been excluded from analyses, owing to the ambiguity of test-question responses when critical information has been forgotten or misunderstood. However this proved unnecessary with the present sample. A pass consisted of naming (or choosing ribbons) of the original color of the dress. Because a majority of the children who failed gave the reality-based response, the level of chance success was conservatively deemed to be 50%.

Pictorial representation: Portrait. Also adapted from Peterson and Siegal (1998), this task had the same girl doll with a new set of brightly colored dresses (i.e., green, orange, pink) as well as a boy doll with a paint set and easel. *E* said: "Here is the boy. Here is the girl. See the girl's dress? What color is it? That's right, it's green. The boy sees her green dress and says . . . " At this point, Peterson and Siegal's instructions had simply stated: "Oh look at your pretty [green] dress. I'll paint a picture of you in your dress." But in case this had failed to make sufficiently explicit the boy's intention to depict color veridically, the present procedure included a more explicit statement, namely: "Oh, look at your pretty [green] dress! I want to paint a picture of you just the way you look in your [green] dress. I will do a painting with your dress the same color as it is right now." From this point on the procedures and wording were identical to the original study, with *E* using the cardboard room and stating: "The boy goes away to finish his painting [hide doll]. He can't see the girl. The girl goes into her room and changes her dress. Now, look! The girl has changed her dress." *E* allowed the child to peek into the room to see the girl in a dress of a new color (e.g., pink).

Three watercolor paintings of the girl doll in either a green, orange (novel), or pink dress were displayed along with swatches of dress fabric. The child was asked the pictorial representation test question: "Which of these pictures did the boy paint?" followed by two control questions, that all children passed: "What color is the dress now?" and "What color dress did the boy see?" To pass the test question, children had to choose the painting of the dress that the girl had originally worn, with chance again set conservatively at 50%.

Results

Table 1 shows the numbers and percentages of children who passed only one, both, or neither task. A total of 20 of the 25 preschoolers (80%) passed the Ribbons test in contrast to only 8 of the 21 (38%) deaf children; this difference was statistically significant, $\chi^2(1, N = 46) = 8.41, p < .01$. The Portrait false-drawing test proved to be significantly easier for the deaf group. Eighteen of these children (86%) passed this test, a level of success no lower than the 88% who passed in the preschool group, $p = .58$, Fisher's Exact Test. Furthermore, when the 11 deaf children who had either passed or failed both tasks were set aside, it was found that the remainder all passed the Portrait test rather than the Ribbons test, a difference that was statistically significant, $p < .01$, two-tailed Sign Test. In other words, in contrast to hearing preschoolers who were close to ceiling on both tasks, these late-signing deaf primary students found it significantly harder to infer the search behavior of a protagonist with a false

Table 1 Patterns of Success and Failure on the Ribbons (False Belief) and Portrait (False Drawing) Tasks of Experiment 1

Group	Pass Both Tasks	Pass Ribbons Only	Pass Portrait Only	Fail Both Tasks	Total
Deaf	8 (38)	0 (0)	10 (48)	3 (14)	21 (100)
Hearing (age 4)	19** (76)	1 (4)	3 (12)	2 (8)	25 (100)
Total	27** (59)	1 (2)	13 (28)	5 (11)	46 (100)

Note: Values in parentheses are percentages; success above chance is denoted $^{**}p < .01$.

belief about a transformed scene, than to predict that a painting would fail to reflect the same transformation.

The fact that normal-hearing 4-year-olds and older deaf children all performed at such a high level on the Portrait task is in line with similar findings of better false-drawing than false-belief performance by normal-developing 3-year-olds (Slaughter, 1998) and by autistic children of a similar age to the present deaf sample (Charman & Baron-Cohen, 1992). Given these similarities, it seems that the high level of false-drawing success reported in these previous investigations was not an artifact of participants having seen the finished drawing before the transformation.

As noted above, Peterson and Siegal (1998) tested a similar group of late-signing deaf children on a version of the Portrait task that did not make explicit the artist's intention to portray color realistically and observed a 62% success rate, which was not significantly lower than the 86% of deaf children who passed the Portrait test in the present experiment, $\chi^2(1, N = 45) = 3.09$, $p > .05$. The Ribbons false-belief test was identical in both studies. Success rates on this task by deaf children (54% and 38%, respectively) did not differ significantly, $\chi^2(1, N = 45) = 1.16$, and were, in both cases, lower than on the corresponding false-drawing tasks. Thus, the more explicit clarification of task demands, although clearly of some benefit, did not appear to be the only factor responsible for the superior false-drawing over false-belief performance by deaf children in Experiment 1.

Discussion

The lower levels of success by the present group of late-signing deaf primary school children than by their 4-year-old hearing peers on the Ribbons false-belief task is in line with much research that has used other standard measures of false-belief understanding and revealed similar delays among deaf children from a wide range of populations, preferred modes of communication, and family and educational experiences, as referenced earlier. Yet the present deaf group had no difficulty with the similarly constructed Portrait task that tested their understanding of an obsolete pictorial, rather than mental, representation.

The deaf children's discrepant performance on the two tasks had been predicted by the hypothesis that representational concepts are shaped by children's early social and conversational experience. When they grow up in hearing families without fluently signing conversational partners, deaf children's opportunities to discuss their own mental states, to converse about imaginary topics, and to be informed about others' false beliefs or mistaken recollections (such as a memory of seeing a dress of a particular color), are severely curtailed. Yet, even in such a family, they could still watch and participate with others in drawing pictures of things in the shared visual space, so that opportunities to notice discrepancies between validly up-to-date versus obsolete or distorted pictorial representations could go on relatively normally. Furthermore, the status of finished paintings and drawings as permanent, public, tangible, and largely nonverbal representations would allow for continuing reflection on them, even in the absence of a common language. Of course, such early awareness of pictorial representation as a physical process of recording visible objects or scenes on paper need not include any notion of the artist's mental involvement in the task. Instead, drawing and other forms of picture making might be viewed as automatic recording processes, perhaps like photography, or the pressing of footprints in the sand, devoid of any mental input from the artist. This raises the question of whether deaf children understand the possibility that a drawing could depict a false version of reality, or could show something purely imaginary, like a mental image of a belief. These issues were examined further in Experiments 2 and 3.

However, the theory of atypical early conversational experiences for deaf children in hearing families is not the only way to account for the results of Experiment 1. A number of methodological differences between the Portrait and Ribbons procedures were unavoidable, and these may have had a differential effect on the performance of the deaf group. One such difference involved the syntax of the test questions. In common with other inferential false-belief tasks, the Ribbons test question lent itself to the present tense phrasing (Which of these ribbons *does* Mum bring?) whereas the physical nature of pictures as representations that gain a tangible existence at a discrete point in time made it more natural to use the past tense for the Portrait test question (Which of these pictures *did* the boy paint?) in both spoken and signed versions. On one account, the greater ease of present than past tense syntax, in both spoken and signed English, might have boosted success on the Ribbons task. On the other hand, the past tense temporal marking of the Portrait test question may have drawn children's attention to the exact moment in the scenario when the obsolete pictorial representation was produced. This linguistic cue could conceivably have made the Portrait test question easier, just as test questions that contain the temporal adverb "first" (Where will she look *first* for X?) are sometimes found to benefit hearing children's false-belief performance (Siegal, 1997; but see also Wellman et al., 2001). Similarly, the artist in the Portait task temporally marked his intent to match color ("the same color as your dress is right now"), whereas in the Ribbons task, the intent to match was simply stated ("ribbons the same color as your dress"). Yet, as noted above, when Peterson and Siegal (1998) tested deaf children on a version of the Portrait task that did not even mention the artist's intent to match color at all, success was not significantly lower than by deaf children in Experiment 1. Thus it seems unlikely that the contrast in performance was purely an artifact of these minor differences in wording. Nevertheless, it is important to further compare deaf children's false-drawing and false-belief performance using test questions with identical syntax; thus, these were goals for Experiments 2 and 3.

Executive functioning deficits (such as memory problems, planning limitations, inflexible thought, or failure to inhibit prepotent response tendencies) have been posited to explain autistic children's failure on false-belief tasks (Bishop, 1993), and it is conceivable that these could also be relevant for late-signing deaf children. The executive demands made by the Ribbons and Portrait tasks were in many ways very similar. Both tasks demanded inhibition of reality-based responding and both made memory demands, although success on memory control questions indicated that these were mostly met. Nevertheless, the Portrait task did differ methodologically from the Ribbons task by using a complete picture of the obsolete scene (the girl in her original dress) as a response option. This may have facilitated performance either by promoting memory of this crucial feature of the scenario or by emphasizing its relevance to the test question. Indeed, Wellman et al.'s (2001) meta-analytic review of normal-hearing children's performance on inferential false-belief tasks indicated benefits from pictures of the outdated information, possibly because the pictures increased the salience of the original situation. Experiment 3 therefore included a direct test of whether children with deafness or autism, as well as normal-hearing preschoolers, could be helped to pass standard false-belief test questions by being allowed to choose between pictures of the mental and real-world contents.

In addition to these methodological refinements, Experiments 2 and 3 aimed to more thoroughly investigate how drawing as a representational activity is conceptualized. Do children view drawing as a purely automatic process, perhaps like photography, in which information is transferred straight from the physical scene to the artist's paper or canvas? Or are they aware of the intervention of the artist's mind, perhaps via a mental image of the scene to be depicted, or in the form of an intentional plan to depict a certain object even before the drawing is begun? The question of the intentions underlying pictorial representation was explored in Experiment 2, whereas Experiment 3 included an assessment of whether children could draw their own mental image of something they had not yet seen.

The question of whether children realize that drawings can represent falsely in other ways than by merely becoming out-of-date also warranted exploration. A more complex and challenging false-drawing test was therefore used in Experiment 2 to examine whether children have an "interpretive" awareness of pictorial misrepresentation (Wellman, 1993). Children do need such an interpretive understanding of belief in order to succeed on false-belief tests (e.g., by interpreting the pictured candies on the outside of a box as the trigger to a belief for a viewer who has not looked inside).

This capacity to cope with interpretive representations that may simultaneously seem true to one mind but false to another goes beyond the average adult's conventional view of photography, according to Sontag (1977 p. 22) who explained: "a photograph passes for incontestable proof that a given event happened. The picture may distort but there is always the presumption that something exists, or did exist, which is like what is in the picture." If this more limited, preinterpretive, conventional conceptualization of pictorial representation is all a child needs to succeed on false-photo tasks and obsolete drawing tasks such as the Portrait task, then such tasks might be intrinsically easier for all children to pass than are standard tests of false-belief understanding. Consequently, owing to the ceiling performance of the hearing control group in Experiment 1, Experiment 2 was designed to further test deaf and hearing children's understanding of pictorial misrepresentation in a more challenging situation that could demand a more sophisticated interpretation of pictorial falsity.

Specifically, in Experiment 2's false-drawing task, children were initially tricked into producing an inherently misleading drawing by being asked to draw a model of a specific color with a marker of a different color (e.g., to draw a green apple with a red pen). Then, a model that exactly matches the drawing (e.g., a red apple) is unexpectedly produced. Children are quizzed on another person's beliefs ("Which will she think you were drawing?") and their own original intentional mental state ("Which one were you trying to draw?"). Thus, to succeed, a child must realize that (1) the model was green (true situation), (2) the drawing is red (false pictorial representation), (3) the other will think the red apple was the model (false belief), and (4) one's own intent was to draw a green apple (representational change). Thus the challenges imposed by this task are at least as great by standard false-belief tests, owing to the necessity for "taking a proposition and decoupling it from its customary reality-oriented implications" (Astington, Harris, & Olson, 1988, p. 14), rather than just appreciating pictorial obsolescence, as in the Portrait test of Experiment 1 and previous false-drawing research. The Candies test was used for comparison and the sample included a group of high-functioning autistic children of similar chronological age to the deaf group.

EXPERIMENT 2

Method

Participants

A total of 61 children (in three groups) was recruited for Experiment 2. There were 26 normal-developing preschool children, who were recruited from the same centers as in Experiment 1 , but had not taken part in Experiment 1. These children had a mean age of 4,6 (*range* = 3,10–5,1) and 14 were male. There were also 14 autistic children who had been diagnosed with autism according to DSM-IV criteria and were attending special schools for autism. All had verbal mental ages of at least 4 years as assessed by the Peabody Picture Vocabulary Test, a mean chronological age of 9,8 (*range* = 5,3–13,3), and 12 were male. The remaining 21 participants consisted of the same deaf children who had taken part in Experiment 1. They were tested approximately 3 months after Experiment 1 and had a mean age of 9,6 (*range* = 6,11–12,11). There was no statistically significant age difference between children with autism versus deafness, $t(33) < 1$, whereas the preschoolers were significantly younger than both of these groups, $F(2, 58) = 72.3$, $p < .001$.

Tasks and Procedure

The children were all tested individually. The deaf children, as before, were tested in their preferred mode of sign language with the assistance of a professional interpreter who used the same comprehension and attention safeguards as described earlier. There were two tasks: (1) a standard misleading container false-belief task, and (2) a novel false-drawing task created for the present study. The standard task employed a familiar Candies box picturing distinctive, multicolored candies with unexpected contents (pencils) and was presented in the normal manner (Gopnik & Slaughter, 1991). After seeing the closed container and naming the expected contents when asked what was in it, children were shown that it actually held pencils. The box was resealed and three questions were presented, in the following order: (1) "X [a classmate] is coming next. He/she hasn't seen inside this box. When I show it to him/her all closed up like this, what will he/she say is in it?" (other's false-belief test question; correct answer = candies); (2) "When you first saw this, what did you think was in it?" (representational change/own false-belief test question; correct answer = candies); and (3) "What is really in it?" (control question; correct answer = pencils). Two children from the preschooler group who failed this latter question were dropped and were not included in the above sample description. After passing the control question, all children were given a Total False-Belief (TFB) score from 0 to 2 to reflect their summed correct answers to test questions. In addition, an overall pass–fail score was given that, by requiring correct answers to both test questions for a pass, yielded an acceptably conservative 25% probability of chance success through random guessing.

The false-drawing task, Apples, opened with *E*'s request that the children draw an apple positioned on a pedestal at eye level. *E* produced a piece of paper and a felt-tip pen of the opposite color to the apple and said: "Now we're going to do some drawings. Here's a pen and paper. Draw this apple here. Draw it the way you see it, the way it looks to you right now." Half of the children in each group drew the red apple with the green pen and the other half had these colors reversed. When the drawing was finished, *E* praised it, left it visible, and put an additional apple of the opposite color beside the first one on the pedestal. Care was taken to match these apples so that, apart from one being completely green and the other completely red, they were identical (e.g., in size, shape, skin texture, stem length, and so forth). For the first few children in each group, this was achieved by carefully shopping for real apple varietals in a well-stocked grocery store. Later, a pair of highly realistic model fruits that most adults initially mistook for real was substituted, with no evident effect on children's responses. The questions (with answers shown for the condition of a green apple model and a red pen) were (1) "When you made this picture, which of these apples were you trying to draw?" (own intent test question; correct answer = green), (2) "Which of these apples was up here when you did your drawing?" (memory control question; correct answer green), (3) "X is coming next. He/she hasn't done any drawings for me yet. I am going to show him/her this picture of yours. I am going to ask him/her to guess which of these apples you were drawing. What will he/she say?" (other's false-belief test question; correct answer = red). Three preschoolers, one deaf child, and one child with autism who were originally tested were not included in the above sample description because they failed the control question. A Total Mental State (TMS) score of 0, 1, or 2 was given to reflect correct answers to test questions and an overall pass required correct answers to both, making the probability of chance success 25%.

Results

Table 2 shows the numbers and percentages of children in each group who passed each task by answering both test questions correctly, as well as children's mean Candies TFB and Apples TMS scores. On the standard Candies task there was no statistically significant difference between the number of children with deafness and the number with autism who passed by answering both test questions correctly, $\chi^2(1, N = 35) < 1$, $p > .20$. However, significantly more of the normal-developing preschoolers passed (73%) than in the deaf and autistic groups combined (46%), $\chi^2(1, N = 61) = 4.57$, $p < .05$, two-tailed. Pass rates for children with deafness versus autism also did not differ on the Apples task, $\chi^2(1, N = 35) < 1$, $p > .20$, but their combined pass rate (71%) on this challenging false-drawing test was significantly higher than that of preschoolers, $\chi^2(1, N = 61) = 16.26$, $p < .001$.

Using the combined TFB and TMS scores, a 3 (groups) × 2 (tasks) ANOVA was conducted with repeated measures on the second factor. There was no statistically significant main effect of either group, $F < 1$, or task $F(1, 58) = 1.65$, $p > .10$; but the interaction between these variables was statistically significant, $F(2, 58) = 8.41$, $p < .01$. As recommended by Keppel (1982), the significant interaction effect was followed up with analyses of simple effects. Results revealed that there was no statistically significant simple effect of group on the Candies task, $F(2, 58) = 1.62$, $p > .20$; but on the Apples task, the simple effect of group was statistically significant, $F(2, 58) = 5.76$, $p < .01$. Simple comparisons showed that the children with autism and with deafness did equally well, $F < 1$, while significantly outperforming the preschoolers, $F(1, 58) = 9.18$, $p < .01$, and $F(1, 58) = 6.50$, $p < .05$, respectively. Analyses of the simple effects of task for each diagnostic group were also conducted. There was a statistically significant simple effect of task for children with autism, $F(1, 58) = 5.40$, $p < .05$, and for those with deafness, $F(1, 58) = 4.69$, $p < .05$. The Apples false-drawing task proved significantly easier than did the standard Candies test for children from both of these groups. The simple effect of task was significant in the opposite direction for the preschoolers, $F(1, 58) = 8.49$, $p < .01$, whose scores were higher on the Candies task than on Apples task. There were no significant correlations between age and Apples TMS scores for any group, nor between Candies TFB scores and age for children with autism or deafness, all ps > .09. For the preschoolers, however, age and TFB scores were correlated significantly, $r(24) = .42$, $p < .05$, two-tailed.

Table 3 shows children's patterns of success on test questions about own mental state on each task. No significant difference emerged between the deaf and the autistic children, $\chi^2(1, N = 35) < 1$, and both groups were adept at recalling their original intention despite discrepancy from the finished picture (pass rates were 90% and 86%, respectively). Only half of the normal-developing preschoolers were similarly successful, and the difference between their poor performance and the high level of success by the combined group of children with deafness or autism was statistically significant, $\chi^2(1, N = 61) = 9.27$, $p < .01$, two-tailed. A total of 42 children in the sample as a whole performed consistently by either passing or failing this question on both tasks. Of the 20 children (4 with autism, 6 with deafness, and 10 preschoolers) who had mixed patterns of success, however, all of

Table 2 **Pass Rates and Mean Scores for the Candies and Apples Tasks of Experiment 2**

	Candies False-Belief Task			Apples False-Drawing Task		
Group	Pass	Fail	*M* (*SD*) TFB	Pass	Fail	*M* (*SD*) TMS
Autistic (*n* = 14)	6 (42)	8 (57)	1.21 (.80)	11** (79)	3 (21)	1.71 (.61)
Deaf (*n* = 21)	10* (48)	11 (52)	1.19 (.87)	14** (67)	7 (33)	1.57 (.67)
Preschool (*n* = 26)	19** (73)	7 (27)	1.58 (.76)	5 (19)	21 (81)	1.11 (.52)
Total (*n* = 61)	35** (57)	26 (42)	1.36 (.82)	30** (49)	31 (51)	1.41 (.64)

Note: Values in parentheses are percentages, unless otherwise noted; success above chance is denoted. TFB = Total False-Belief score; TMS = Total Mental State score.
$^*p < .05$; $^{**}p < .01$.

Table 3 Number of Children Passing and Failing Test Questions about Own Mental State on Candies (Standard) and Apples (False Drawing) Tasks of Experiment 2

	Own Prior Intent (Apples Task)								
	Autistic Children			Deaf Children			Preschoolers		
	Pass	Fail	Total	Pass	Fail	Total	Pass	Fail	Total
Own Prior Belief (Candies task)									
Pass	8 (57)	0 (0)	8 (57)	13 (62)	0 (0)	13 (62)	12 (46)	8 (31)	20 (77)
Fail	4 (29)	2 (14)	6 (43)	6 (28)	2 (9)	8 (38)	2 (8)	4 (15)	6 (23)
Total	12 (86)	2 (14)	14 (100)	19 (90)	2 (9)	21 (100)	14 (54)	12 (46)	26 (100)

Note: Values in parentheses are percentages.

those who had either deafness or autism passed this question only on the Apples task, compared with only 2 of the 10 preschoolers, a difference that was statistically significant, $\chi^2(1, N = 20) = 13.33, p < .01$.

Table 4 shows how children performed on the test question about the other person's false belief on each task. Similar proportions of children in each group showed consistent patterns by either passing the question on both tasks (48% overall) or failing it on both (16%); however, patterns of task-specific success and failure differed significantly for the 22 children who answered the question about the naive other's false belief correctly on one task and wrongly on the other. Seventy-three percent of the 11 children with mixed false-belief accuracy from the combined group with deafness or autism (67% and 80% of these respective groups separately) passed on the Apples task while failing on the Smarties™ task; whereas only 27% of the 11 preschoolers with mixed accuracy did so, $\chi^2(1, N = 22) = 4.55, p <. 05$, two-tailed.

Discussion

The very sound levels of understanding of obsolete and false mental states for self and other that these deaf children, like their peers with autism, managed to achieve on the challenging Apples false-drawing task are striking in both absolute and relative terms. In an absolute sense, between 85% and 90% of these children were able to correctly recall their own original mental state on the drawing task, despite the discrepancy from visible reality. However, their performance on the standard task was no better than chance, in line with much previous research with children from these populations. Similarly, although many deaf and autistic children in Experiment 2 could accurately infer the other's false belief about the model for their drawing, they were mostly incapable of correctly inferring this same naive other's false belief on a standard task in which the similarly privileged information involved a closed container.

Relative to the performance by the normal-developing preschoolers, these discontinuities between deaf and autistic children's unexpectedly good false-drawing performance and poor standard false-belief understanding were even more striking. The Apples false-drawing task was designed to be more challenging than was the false-drawing tests that had previously been used, not only in Experiment 1, but also in

Table 4 Number of Children Passing and Failing Test Questions about the Other's False Belief on Candies (Standard) and Apples (False Drawing) Tasks of Experiment 2

	Other's False Belief (Apples Task)								
	Autistic Children			Deaf Children			Preschoolers		
	Pass	Fail	Total	Pass	Fail	Total	Pass	Fail	Total
Others' False Belief (Candies task)									
Pass	7 (50)	1 (7)	8 (57)	10 (48)	2 (9)	12 (57)	12 (46)	8 (31)	20 (77)
Fail	4 (29)	2 (14)	6 (43)	4 (19)	5 (24)	9 (43)	3 (11)	3 (11)	6 (23)
Total	11 (79)	3 (21)	14 (100)	14 (67)	7 (35)	21 (100)	15 (58)	11 (42)	26 (100)

Note: Values in parentheses are percentages.

most published research. The low level of success on Apples that was attained even by normal-developing preschoolers who performed at cei1ing on the standard Candies task suggests that this methodological objective was achieved and that the Apples task was not just intrinsically easier than the Candies task. Nor can a pictorial ToM, on this evidence, be deemed to be a universal precursor to a classic ToM as assessed by standard false-belief tests, even though such a possibility has been suggested by other investigators (Freeman & Lacohee, 1995).

How can these deaf and autistic children's superior understanding of false beliefs in a drawing context conceivably be explained? One possibility, as was initially hypothesized, is that late-signing deaf children (like their peers with autism, although for different etiological reasons), may be able to gain an early insight into the mental states of self and others when they revolve around the familiar and largely nonverbal activities of picture making and picture interpretation, even in the absence of a fully generalized representational ToM. In other words, skilled understanding (1) of drawings as potentially obsolete representations (as in Experiment 1), and (2) of the intentions and beliefs surrounding the act of drawing (as in the Apples task) may reflect the first budding awareness of mental representation on the part of children whose disabilities may, in different ways, curtail access to conversations about many other kinds of mental states.

However, it is also conceivable that the differences observed in many children with autism and deafness who succeeded on the Apples task while failing on the Candies task may have reflected methodological attributes of these two tasks. Indeed, there were a number of obvious differences between their respective procedures. For one thing, the Apples task asked about own mental state of intention, in contrast with belief on the standard Candies task. If false belief is an intrinsically more difficult concept than intention, this could account for discrepancies in performance on this question for the children with autism and deafness who did better on the Apples task. However there is evidence that intention is not intrinsically easier than false belief, at least for normal-developing preschoolers. Gopnik and Slaughter (1991) gave normal-developing 3- and 4-year-olds the standard false-belief task along with a changed-intention task in which they were initially asked to draw a ball. When they had sketched its round outline, the experimenter replaced the model ball with an apple and asked children to alter their drawings to depict it (e.g., by adding a stem). Children in both age groups did no better on the changed-intention test question ("When I first asked you, before you started drawing, what picture were you trying to draw then?") than on the standard test question about what they had first thought the candies box contained.

However, a suggestion that changed intentions with regard to drawings might, indeed, be easier for autistic children to understand than are false beliefs about misleadingly labeled containers emerged from a recent study by Russell and Hill (2001). In their study, as part of a larger investigation of executive functioning and ballistic intent–outcome discrepancies, a sample of autistic children of similar age and ability to those tested in Experiment 2 was presented with a standard container false-belief task and a "transparent intentions" task that tested comprehension of failed intentions with regard to drawings. Specifically, for the drawing-intentions task, children were asked to finish a partially completed sketch in a specific way (e.g., to add an ear to the face of a boy with dark hair). Without the child's realizing it, a clear plastic transparency sheet containing a simpler outline (e.g., of a coffee cup) had been invisibly placed on top of the darker face picture so that the child had actually drawn the handle of the cup, not an ear. The representational change question assessed (now false) intent by asking: "Remember when you did the drawing, did you mean to draw an ear or a handle?" There was also a third-person version in which children watched a puppet being similarly duped. The children with autism performed remarkably well (63% were correct across first- and third-person intent conditions combined) and at as high a level as a chronological age- and verbal age-matched control group with moderate learning difficulties. Yet this control group significantly outperformed the group with autism on a standard false-belief test question about misleading contents (only 52% of those with autism answered it correctly).

This could indicate, as Russell and Hill (2001) suggested, that concepts of intentionality are inherently easier than are concepts of belief for children with autism. However, another possible explanation could be that these children find it easier to understand all false mental states more readily in the context of deceptive drawings than of misleadingly marked containers, consistent with the high level of success shown by the autistic group on the Apples false-belief question, as well as with the sound performance by the autistic children in Russell and Hill's study (63% correct) on a false-belief question about the transparency drawing ("When you did the drawing did you think you were drawing an ear or a handle?").

However, a more complete test of these possibilities requires the inclusion of a complementary condition in which children and asked about obsolete intentions in a standard false-belief situation. This was one of the aims of Experiment 3. The possibility that children with autism (and possibly those with deafness) find concepts of intention generally easier than concepts of false belief predicts better performance on the changed-location intention task used in this study than on a matching standard changed-location false-belief task. However, if the use of scenarios about drawing accounted for these groups' higher levels of success on the Apples task as opposed to the Candies task, no difference should emerge between intent and belief tasks in Experiment 3.

The Candies task of Experiment 2 demanded that children predict the consequences of false beliefs for others' speech ("What will X say is in it?"). However, it is also possible to devise a task in which the response modality for a misleading container task entails predicting the consequences of a false belief for drawing ("If I ask X to draw what is in here before I open it, what will he draw?"). If children with deafness or autism have specific difficulties with understanding how thinking leads to the verbal expression of those thoughts in speech or sign, they may find it easier to pass such an inferential false-belief task in which they can respond with a visual image of the belief—for example, by producing or selecting a drawing of it. This possibility also was tested in Experiment 3, along with the possibility that a variable shown to improve normal-developing children's false-belief performance in Wellman et al.'s (2001) meta-analytic review might have proved beneficial to the deaf and autistic participants in Experiment 2; namely, active involvement in creating the deceptive stimulus. For the Apples task, children created the misleading stimulus drawing after having been tricked themselves by the switch of pens, but in the Candies test they were mere passive observers of the box's unexpected contents. Consequently, a subsidiary comparison was included in Experiment 3 between the standard candies procedure and container task in which the participants themselves actively created the deception.

EXPERIMENT 3

Method

Participants

The sample consisted of 13 deaf children, 8 children with autism, and 26 normal-developing preschoolers. The deaf children had a mean age of 8 years, 11 months (*range* = 7,7–11,10) and 6 were boys. They were tested as described earlier, with the assistance of a professional interpreter who was fluent in their mode of sign language. Nine of these children had previously participated in Experiment 2. The children with autism had a mean age of 8,3 (*range* = 5,9–10,8) and 6 were boys. They had all been diagnosed according to DSM-IV criteria and were attending a special school for autism. Three of these autistic children had taken part in Experiment 2. The preschoolers were drawn from the same centers that had supplied the samples for Experiments 1 and 2, but none had participated in either of these earlier studies. They had a mean age of 4,7 (*range* = 4,0–5,3) and 14 were boys.

Tasks and Procedure

Each child was individually tested on six false-belief tasks, with the order of the tasks randomly varied within each group in all possible combinations.

Standard misleading container (Candies). This task was identical to that of Experiment 2 except that the question about own belief was omitted (to minimize fatigue effects) and alternative containers of similar attractiveness, labeling, and familiarity (a cheese puff bag containing a small shoe, or a chocolate box containing candles) were used as substitutes for those deaf or autistic children who had received the task using candies in Experiment 2. The test question was: "X [a classmate] is coming next. He/she hasn't seen inside this box. I am going to show it to him/her all closed up like this and ask him/her to tell me what is in it. What will X say?"

Draw Beliefs. This new misleading container task was identical to the previous task except for the use of drawing as the response modality. Children were shown a closed crayon box with familiar labeling and *E* said: "See this box here? I wonder what is in it? Can you draw me a picture of what is in this box?" At this point, most children drew something that looked recognizably like crayons or pencils (e.g., lines or oblongs). The prompt: "Guess what's in here and draw it" was given if the child hesitated, and "So what's that a picture of?" was asked if the drawing was not self-evident to the adult(s). The box was then opened to reveal buttons and resealed. *E* said: "X [a classmate] is coming next. He/she hasn't seen inside this box. I am going to show it to him/her all closed up like this and ask him/her to draw what is in it. What will X draw? You draw that here." (Note that the syntax of this question was the same as in the standard task). As before, *E* prompted, "What's that a picture of?" if the drawing was ambiguous. Responses to the test question were scored as correct if they unambiguously depicted one or more crayons, or if the child said an unrecognizable drawing was a crayon. Drawings of buttons, or of some irrelevant item (e.g., a turtle, a man, a candle, a numeral, a spider, and so forth.) or a scribble that the child called a button, were all scored as incorrect.

Choose Drawing. This task resembled the previous one except that the child was allowed to choose between completed drawings, instead of having to produce them. A container with a familiar label that showed round marble-sized candies was presented closed up and *E* said: "See this box here? I wonder what is in it. Here are two pictures." [*E* displayed a very simple line drawing of four round circles and another of four straight lines]. Which one shows what is in the box?" After the child selected the circles (which all did), the true contents of the box (matches) were displayed. Having closed the box, *E* asked the test question: "X [a classmate] is coming next. He/she hasn't seen inside this box. I will show him/her this box all closed up like this and ask him/her to draw what is in it. Which of these looks like the picture that X will draw?" (same picture choices; correct answer = round circles).

Active Deception. This task resembled the standard container task except that the child was an active conspirator in creating the deceptive stimulus that was framed in terms of a trick. A new but equally familiar container (a potato chip tube) was shown closed up. After initially guessing that it held chips (which all participants did), children were given a set of small objects (a toy insect, a plastic flower, a brush, and a wrapped chocolate frog) and were told: "No see? It is empty. X [a classmate] is coming next. Let's play a trick on him/her. Let's put something in here. You pick one of these and put it in. Just one thing. That's right. Now close it up. So what have you put in there?" (This was a control question to which all children responded correctly). Then *E* asked the standard test question (correct answer = chips). When children answered incorrectly, they for the most part named the substitute contents or, occasionally, one of the other decoys.

Changed Location False Belief. This was the first trial of Baron-Cohen, Leslie, and Frith's (1985) Sally-Ann task (in which a doll relocated a marble from a closed basket to a closed box during the absence of the doll who had initially put the marble in the basket), presented and scored exactly as described by the original authors apart from the substitution of a boy doll for the second female doll. The test question, "Where will the girl look for her marble?" was followed by a pair of control questions for memory and attention to the object's present location, which all children passed.

Changed-Location Intent. Similar to the Changed-Location test, a boy doll first placed some real coin money into one container (depending on counterbalancing, either a bag or a box) and a ball into another (e.g., box), then left the scene. A witch entered, switched both items into opposite containers and disappeared. The boy returned and *E* asked the test question. "The boy is coming back. He is going to the bag. What is he trying to get?" (If there was no response or an ambiguous one, *E* prompted: "Is he trying to get his money to go shopping or is he trying to get his ball to play with?"). Two control questions followed, which all children passed: "Where is the money really?" and "What is really in the bag?"

Results and Discussion

Two sets of preliminary analyses were conducted. The first checked that the drawings that children produced before looking into the crayon box were recognizable by two independent adult judges. In a majority of cases (i.e., for 85%, 88%, and 62% of the deaf, autistic, and preschool children, respectively) this was the case, even without the child's verbal label; and in 100% this was the case with the label. Furthermore, the vast majority (85%, 88%, and 96%, respectively) had drawn one or more crayons (the remainder drew items such as an insect or a candle, which had been used at other points during testing). Thus, these children's accurate depiction of something they had not yet seen, but could only imagine, testified to sound executive skills for planning and mental imagery, in line with the conclusion by Harris and Leevers (2000, p. 193) that "children with autism have an intact capacity for visualizing familiar scenes or entities and for recombining elements to form a new image."

The second set of preliminary tests explored the possibility of carry over effects for the children with deafness or autism who, owing to membership in populations of limited size, had been recruited for Experiment 3 after already having already taken part in Experiment 2. The relevant comparison was between the two standard misleading container tasks, because the Apples test of Experiment 2 had no direct counterpart in Experiment 3. Of the 3 autistic children who took both the standard Candies test in Experiment 2 and the substitute (misleading container) test in Experiment 3, 1 child passed in both studies and the other 2 failed in both. Similarly, out of the 9 deaf children who took part in both experiments, 4 failed the standard test in both studies, 3 passed in both, 1 passed in Experiment 2 but failed in Experiment 3, and 1 passed in the latter and failed in the former. Thus, there was no indication that children in either of these groups had been influenced by previous participation in a similar testing procedure with different stimuli. Of course, it was possible that within

Experiment 3, children's performance on later tasks may have been influenced by earlier ones. However, random allocation of task order in all possible combinations ensured that this would not systematically distort any group's performance.

For the main statistical analysis that compared the three groups' levels of understanding of drawing-related false beliefs with standard verbal ones, each child was given a Drawing Belief (DB) score of 0, 1, or 2 as the sum of scores on Draw Beliefs and Choose Drawing, along with a TFB score that summed the two standard tasks (Sally and Candies). Using these scores, a 3 (groups) × 2 (task sets) ANOVA was conducted with repeated measures on the second factor. There were no statistically significant main effects of either group, $F(2, 44) = 1.00$, $p > .20$, or task set, $F(1, 44) = 1.67$, $p > .10$, but the interaction between these variables was statistically significant $F(2, 44) = 3.25$, $p < .05$. As recommended by Keppel (1982), this significant interaction effect was followed up using simple effects analyses, followed by simple comparison tests. There was a statistically significant simple effect of diagnostic group on TFB scores, $F(2, 44) = 3.74$, $p < .05$, but not on DB scores, $F < 1$. Simple comparisons showed that the mean TFB scores of .92 and .88 for the deaf and the autistic children, respectively, did not differ significantly, $F < 1$. But the preschoolers, with a mean of 1.50, scored significantly higher on the standard tasks than did the children with autism, $F(1, 44) = 4.33$, $p < .05$, or with deafness, $F(1, 44) = 4.54$, $p < .05$. Analyses of the simple effects of task type on children in each group were also conducted. The task simple effect was statistically significant for the deaf children, $F(1, 44) = 4.60$, $p < .05$, who scored higher on the drawing tasks than on the standard ones; but there was no significant simple task effect for the children with autism, $F < 1$, or for the preschoolers $F(1, 44) = 2.30$, $p > .10$.

Table 5 shows the numbers and percentages of children in each group who passed the test question about the other person's mental state on each Experiment 3 task. There were no statistically significant differences among the three groups on any of the misleading container tasks, all $\chi^2(1)$ values < 1, or between the children with autism versus deafness on any of the tasks, all $\chi^2(1)$ values < 1. However, the preschoolers significantly outperformed the combined group who had deafness or autism on the standard Changed-Location False-Belief test, $\chi^2(1, N = 47) = 5.71$, $p < .05$.

To assess possible differences between the different types of drawing-related false-belief tasks that were used in Experiments 2 and 3, comparisons were made, for children from each diagnostic group separately, of overall success on these studies' respective drawings composite scores. The mean DB score of 1.38 for the Experiment 3 deaf children was not significantly lower than the mean Apples task TMS score of 1.57 for the deaf children who took part in Experiment 2, $t < 1$. With respective means of 1.12 and 1.71, the groups with autism in each study likewise did not differ significantly, $t(20) = 1.66$, $p > .10$, two-tailed, and the respective groups of preschoolers scored almost identically in both studies ($M = 1.13$ and 1.11, respectively), $t < 1$.

As in Experiment 2, there were no statistically significant correlations between age and either DB scores for the deaf or the autistic children, or TFB scores for any of the groups, all $ps > .08$. For preschoolers, however, age was a marginally significant predictor of DB scores, $r(24) = .39$, $p = .05$. Furthermore, in contrast to the Experiment 3 children with deafness or autism, who performed comparably on each drawing-related task, the preschoolers did significantly worse on Draw Belief than on Choose Drawing, $p < .05$, two-tailed Sign Test.

Executive functioning problems might well have explained preschoolers' problems producing, rather

Table 5 Number of Children Passing False-Belief Test Questions in Experiment 3

	Standard False Belief			Modified Tasks		
Group	Candies	Changed Location	Active Deception	Draw Beliefs	Choose Drawing	Changed-Location Intent
Deaf ($n = 13$)	7 (54)	5 (38)	7 (54)	9 (69)	9 (69)	9 (69)
Autistic ($n = 8$)	3 (38)	4 (50)	4 (50)	4 (50)	5 (62)	6 (75)
Preschool ($n = 26$)	19* (73)	20* (77)	18 (69)	13 (50)	20* (77)	20* (77)
Total ($n = 47$)	29 (62)	29 (62)	29 (62)	26 (55)	34** (72)	35** (74)

Notes: Values in parentheses are percentages; success above chance is denoted.
*$p < .05$; **$p < .01$.

than simply selecting, a drawing of a false belief that itself had to be inferred from the experimental situation. Indeed the test response drawings that some of the preschoolers who failed Draw Belief produced (e.g., a numeral, the letter A, an egg, and a spider) were consistent with the possibility of interference from planning or working memory problems. Interestingly, however, there was no selective disadvantaging of the children with deafness or autism by the complex planning demands of this task, relative to preschoolers. Instead, every deaf or autistic child who failed the Draw Belief test question did so by producing a drawing of the real contents of the box (buttons) that was clearly independently recognizable without a verbal label.

The possibility that other task factors shown to boost normal-developing preschoolers' false-belief performance in previous research (Wellman et al., 2001) had exerted a similar influence in this study was tested with a series of Sign Test contrasts of selected tasks for each diagnostic group separately. The hypothesis of facilitation through availability of a picture of the false belief during test questioning was tested by comparing pass rates on the Choose Drawing task with the Candies task. There were no statistically significant differences for any of the groups, all *p*s $>$ .25. The hypothesis that active participation by the child, along with explicit mention of deception, would be beneficial was tested by comparing the Candies task with the Active Deception task. No statistically significant difference emerged for any of the groups, all *p*s $>$ .25. Finally, the hypothesis that failed intent could be an easier mental state to comprehend than false belief was tested by comparing the Changed-Location Intent task and Changed-Location False-Belief task. No statistically significant differences emerged, all *p*s $>$ .25. Thus neither pictorial support, active deception, nor a differential grasp of intentional mental states relative to belief seemed tenable as explanations for the higher levels of success displayed on the Apples task than the Candies task questions by the children with deafness and autism who had taken part in Experiment 2.

GENERAL DISCUSSION

As in much previous research, the results of the present experiments confirmed the existence of delays in ToM development, as assessed by "litmus" false-belief tests (Astington, 2001), for high-functioning children with autism and late-signing deaf children from hearing families. At mean ages of around 8 years, children from each of these special populations scored significantly lower on standard false-belief tests than did normal-developing 4-year-olds in Experiments 1 and 3. However, the combined results of all three experiments suggested better performance by children with deafness and with autism on false-belief tasks that involved drawings than on closely matched standard versions of the inferential false-belief procedure, whereas when normal-developing preschoolers showed differential success on false-drawing and false-belief tasks, it was often in the opposite direction. Thus, like autistic children tested in previous research (Charman & Baron-Cohen, 1992; Peterson & Siegal, 1998), the Experiment 1 deaf children were significantly better at predicting the outcome of a painting that represented an obsolete scene than the search behavior of a protagonist with an obsolete belief, whereas the hearing preschool control group scored equally high on both tasks. In Experiment 2, when the false-drawing procedure was made more challenging by introducing a trick that led children to create a misleading picture, children with deafness or autism did exceptionally well, and were better than were normal-developing 4-year-olds at recalling their now-false intentions and accurately predicting the false beliefs that the misleading drawing would inspire in the mind of a naive viewer. Yet, on a standard misleading container task that, apart from not using pictures, had many similar features, their accuracy rarely exceeded chance.

The results of Experiment 3 were similar to those of Experiment 2. On a pair of false-belief tests that involved drawings, older children with deafness or autism did as well as normal-developing preschoolers, despite being outperformed by the preschoolers on a standard pair of false-belief tests that involved changed locations of objects and deceptive containers. Furthermore, the results of the systematic comparisons that were included in Experiment 3 among the various methodological inconsistencies and minor variations in wording that existed between several of the false-belief and false-drawing tasks made it clear that these procedural artifacts could not fully account for the differentially better performance shown by children with deafness and autism on measures that involved drawing than on standard ToM tests.

Possibly these observed patterns of difference in the relative ease with which children in these groups comprehend drawing-based, versus language-based, false belief may reflect the unique input of children's early social and conversational experience. As noted earlier, Tager-Flusberg's (1993) observational studies have shown that in their spontaneous conversations with family members, children with autism rarely discuss cognitive mental states such as false belief. Such conversations are also likely to be both difficult and infrequent for late-signing deaf children who grow up in hearing families without partners for conversations about things that are not immediately present in the shared visual space (Marschark, 1993; Meadow, 1975). Yet these kinds of conversations arise frequently in the homes of normal-hearing 3- and 4-year-olds who have fluent parental and sibling conversational partners (Dunn, 1994), so that "on hearing what another person says out loud, normal children can readily take that utterance to be consistent with what that person privately thinks" (Harris & Leevers, 2000, p. 197), even when the referent is a belief that is purely imaginary or false.

Yet, given the unique characteristics of their respective disabilities and social circumstances, it is still possible that some routes into gaining insight into the minds of others could remain open for children with deafness or autism who, for different etiological reasons, lack these kinds of early family conversational experiences. Drawings and pictures, as concrete and largely nonverbal representations, are part of the domestic and school experiences of these children who draw and paint frequently and pass normally through all the stages of representational drawing development at typical ages (Charman & Baron-Cohen, 1993). Consequently, by drawing pictures, watching others draw, and comparing their finished works with visible reality, children with deafness or autism might gain some circumscribed insight into the mental states that are bound up with the creation and interpretation of drawings, and might achieve an early, although fragile, grasp of their own and others' true and false beliefs about realistically intended drawings. Yet it would seem that such understanding is specific to thoughts about pictures rather than fully generalizable across all content areas.

In other words, in the same way that "stories and adult conversation bring mental states to children's attention" (Astington, 2001, p. 686) in families with preschoolers of normal hearing, both private and socially shared drawing and picture recognition activities may bring drawing-oriented mental states to the attention of children with deafness or autism. The present results do suggest, however, that these picture-related insights may not readily extend themselves to other facets of the ToM, because the deaf and autistic children in the present studies who passed false-drawing tasks often did poorly on standard false-belief measures. For autistic children, this lack of generalizability is also supported by the results of training studies that showed minimal benefits of successful pictorial training for other kinds of nonpictorial false-belief tests (e.g., McGregor et al., 1998; Swettenham et al., 1996).

Social experience differences might also be implicated in the strikingly better false-drawing understanding displayed by the Experiment 2 deaf and autistic children than by the preschool comparison group on the Apples task, despite similar performance on the standard Candies task. However, the fact that children with deafness and with autism did exceptionally well on the Apples task is in line with Russell and Hill's (2001) similar finding in children and adolescents with autism of a surprisingly sound understanding of false intentions about drawings using a somewhat different testing procedure. Perhaps years of classroom exposure to drawing and painting activities in school, as well as many years of informal involvement in artistic play and creative pursuits with peers and family members at home, had helped these older children from special populations to become aware of mental states bound up with drawing, in contrast to younger preschoolers who, possibly owing also to executive functioning difficulties, had more trouble with all phases of the productive Draw Beliefs task of Experiment 3 than did children in the deaf and autistic groups.

A developmentally emerging concern with pictorial realism might likewise have selectively assisted the groups of children with autism and deafness on the false-drawing tests used in all of these experiments. According to Freeman (1993, p. 115), "Between the ages of 5 and 7 years children [come to] have a conception of getting a picture right so you can see what it's about." At age 4, the preschoolers in Experiment 3 may not yet have grasped this necessity for a match between a realistically intended picture and its model as clearly as did deaf and autistic children who were on average 5 years older.

Reasoning along similar lines with regard to the role of experience in ToM development by children with autism, Harris and Leevers (2000, p. 196) suggested that: "It is conceivable that autism does not prevent the attainment of a relatively normal awareness of certain mental states, notably those involving visual imagery." They speculated that autistic children may find it hard to recognize a link between what people say and what they think because their own minds are organized in a more pictorial manner around visual images and nonlinguistic mental imagery. If so, then whereas for normally developing children, "the most obvious external analogue of thinking is speaking," for the autistic child "a more accessible analogy [may be] between 'pictures in the head' and external images, be they pictures, drawings or photographs" (Harris & Leevers, p. 198). It is conceivable that the same could be true of signing deaf children, whose performance on memory tasks that involve pictorial imagery often exceeds that for words, and whose spatial memory spans are sometimes found to exceed those of their normal-hearing age peers (Emmorey, 1998). Whether this reflects early exposure to drawing as an accessible mode of representation akin to thought, or perhaps the cognitive benefits of sign language for spatial cognition (Courtin & Melot, 1998), or possibly some other root cause altogether, is, of course, open to speculation that cannot be resolved on the basis of present evidence. Nevertheless, the act of drawing could prove to be a promising adjunct to purely verbal exchanges of information about mental states in the family and at school because, as Harris and Leevers (2000, p. 198) noted, pictures may offer children with autism (and by this logic also late-signing deaf children) "an external and understandable analogue of their primary mode of thinking, namely visual imagery."

Further empirical research is now needed to confirm and extend the patterns tentatively sketched by the present results. It will also be important, in future studies, to directly observe and examine children's spontaneous involvement at home and at school in pictorial representational tasks such as drawing, picture interpretation, or map making. It is worth studying the ways in which such socially shared activities unfold themselves, the manner in which representational successes and failures are perceived and commented on, and children's discussions or disputes over how physical and pictorial worlds are linked, to gain a clearer understanding not only of the possible influences of these kinds of experiences on concepts of false belief, but also to clarify the broader question of how everyday social experiences—including artistic play and conversations about pictures, like family talk in general, may interact with core neurocognitive processes, and with developmental, sensory, and communication-modality variations among groups of children, in the growth of a ToM.

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