

What's Communication Got to Do With It? Gesture in Children Blind From Birth

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It is widely accepted that gesture can serve a communicative function. The purpose of this study was to explore gesture use in congenitally blind individuals who have never seen gesture and have no experience with its communicative function. Four children blind from birth were tested in 3 discourse situations (narrative, reasoning, and spatial directions) and compared with groups of sighted and blindfolded sighted children. Blind children produced gestures, although not in all of the contexts in which sighted children gestured, and the gestures they produced resembled those of sighted children in both form and content. Results suggest that gesture may serve a function for the speaker that is independent of its impact on the listener.

When people talk, they gesture. With movements of their hands, speakers indicate size, shape, direction, and distance, lend emphasis to particular words, and highlight essential phrases. Gestures have been observed in children before they can talk (e.g., Acredolo & Goodwyn, 1988; Bates, 1976) and in speakers from a variety of cultural and linguistic backgrounds (see Feyereisen & de Lannoy, 1991). Because gesture is less codified than speech and has the potential to convey information imagistically (McNeill, 1992), meanings not easily encoded into speech can be conveyed in the accompanying gestural stream. As a result, gesture can convey information that is not explicitly encoded in speech, thus providing a unique window into the mind of

the speaker (Alibali & Goldin-Meadow, 1993; Goldin-Meadow, Alibali, & Church, 1993).

These observations suggest that gesture can play an important role in communicative situations—but does it? In a comprehensive review, Kendon (1994) provided evidence that the gestures produced along with speech do play an integral role in communication. Gesture is attended to by listeners and can substantially affect the message that the listener abstracts from the communicative act. For example, McNeill, Cassell, and McCullough (1994) have shown that when adults were asked to listen to a narrative in which gesture and speech were deliberately manipulated to convey different information, they attempted to reconcile the discrepancy between the two modalities in their retelling of the story. Along similar lines, Goldin-Meadow, Wein, and Chang (1992) reported that when adults were asked to observe a series of children explaining their responses to a Piagetian conservation task, they incorporated information that the children conveyed only in gesture into their verbal assessments of the children's reasoning about the task (see also Alibali, Flevaris, & Goldin-Meadow, 1997; Goldin-Meadow & Sandhofer, 1996). Thus, information conveyed in gesture is accessible to listeners and is frequently incorporated into the message that a listener takes from a situation. Gesture, in other words, often plays a communicative role for the listener.

The question we address in this article is whether speakers will gesture if they have had no first-hand experience with the communicative value of gesture. In other words, are gestures produced solely for the benefit of the listener, or do they play a role for the speaker as well?

Speakers are known to gesture in situations where no observer is present to appreciate the output of this act. For example, speakers gesture when talking on the telephone or when they have their backs turned to their listeners (e.g., Rimé, 1982). Note, however, that in these situations, a speaker who has had life-long visual experience with face-to-face interaction might simply produce gesture out of habit, or with an imaginary listener in mind—not out of a need to gesture for the self. On this view, gesturing may have been originally established on the basis of the communicative function it played for listeners. The

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fact that speakers continue to use gesture when no listener is available simply means that the communicative requirements of the listener need not be physically present for the speaker to gesture.

In order to tease apart the communicative role that gesture plays for the listener from any role it might play for the speaker, we must examine gesture production in individuals who have had no experience whatsoever with the communicative value of gesture. Individuals who have been blind from birth are an ideal population in which to explore this question because they have never seen gesture produced in communication situations and thus have no first-hand knowledge of the ways in which gesture can enhance a spoken utterance.¹ If these individuals gesture despite their lack of experience with the communicative uses of gesture, we will have evidence that gesturing is an essential part of speaking—an act that speakers perform for themselves as well as for their listeners.

Despite the fact that the blind population is of great potential importance to researchers seeking to explore the functions of gesture, very few investigators have examined gesture use in individuals who have been blind from birth. With respect to mature speakers, only two studies have made any systematic attempt to determine whether blind adults gesture spontaneously and to describe the form that such gestures might take. In one study, Manly (1980) analyzed the nonverbal behaviors produced by a small group of adults blind from birth in an informal conversational situation using Ekman and Friesen's (1972) typology of nonverbal behavior. She found some instances of adaptors (body manipulators) and regulators (changes in body posture that signal the end of a conversational turn), but no occurrences of illustrators (movements that are closely tied to the content and flow of speech). Similarly, Blass, Freedman, and Steingart (1974) asked groups of blind and sighted college students to give a 5-min monologue about an event of personal significance, and found that students who were blind from birth produced virtually no illustrators, particularly in comparison with the sighted students.

Further, despite the substantial body of research devoted to the acquisition and use of spoken language in children blind from birth (e.g., Andersen, Dunlea, & Kekelis, 1993; Dunlea, 1989; Landau & Gleitman, 1985), very few studies have systematically examined nonverbal communication in young blind children. A number of anecdotal reports suggest that, like blind adults, blind children do not gesture at all (e.g., Apple, 1972; Mills, 1988). However, McGinnis (1981) observed some use of communicative gesture, either with or without accompanying verbal expressions, in blind preschoolers conversing informally with an experimenter. Similarly, Parke, Shallcross, and Andersen (1980) found that blind children used head nods appropriately in conversation, although the children produced those nods in a narrower range of circumstances than did sighted children.

In a study of even younger blind children, Urwin (1979) reported that none of her 3 blind participants produced request gestures or communicative points during the preverbal period. However, there was some suggestion that the blind children did use other types of gestures in their attempts to communicate. Although Urwin's (1979) children failed to point, they did make use of "sophisticated forms of body play" (p. 121) to attract the attention of their caregivers. More recently, Preisler (1993)

confirmed findings previously reported by Dunlea (1989) and Urwin indicating that blind children made use of repeated body movements to request the continuation of an activity, and that the first symbolic, communicative acts produced by blind infants were expressed by body or hand and arm movements related to a certain action (e.g., bathing). In short, although blind infants do not appear to produce the pointing and requesting gestures that are commonly observed among young sighted children, they may use other hand and body cues in their early efforts to communicate with others.

Taken together, these results have been interpreted as an indication that, relative to sighted individuals, blind adults and children make limited use of gestures. But because gesture in blind individuals has been assessed in only a relatively narrow range of contexts, this conclusion may be premature. Before concluding that blind individuals make limited use of gesture, this range must be extended to situations that foster direct comparisons with sighted individuals.

Thus, the purpose of this study is to observe the communications of children blind from birth in three different discourse situations, all of which have been shown to elicit gesture production in sighted children:

1. A conservation task: Church and Goldin-Meadow (1986) found that of the 134 children they tested on Piagetian conservation tasks, only 1 child failed to gesture on the tasks; the blind children in our study were asked to reason about invariance across transformation in a series of conservation tasks.

2. A directions task: Gesture is almost inevitable in sighted individuals when they are asked to give directions (McCullough, 1995); the blind children in our study were asked to give directions to a series of known locations.

3. A narrative task: Gesture frequently accompanies the narratives told by sighted individuals when asked to recount a story (McNeill, 1992); the blind children in our study were asked to retell a story to a listener.

To establish a standard against which gestures of blind children could be compared, we administered the three tasks to an age-matched group of sighted children. In an attempt to assess the effects of a temporary loss of vision on the production of gesture, half of the sighted children in the comparison group performed the three tasks while wearing a blindfold, and half performed the tasks with vision unimpeded. For each task, we first examined whether the blind children gestured despite the fact that they had never seen gesture produced. If so, we then explored whether their gestures were comparable in form and content to those produced by sighted or blindfolded children.

Method

Participants

Participants for the study were 4 blind boys aged 10 years 1 month, 10 years 10 months, 11 years 7 months, and 12 years 5 months. All 4

¹ Blind students are told in forensics and drama classes that they ought to move their hands when speaking, but they are not given gesture forms or told when to gesture. Data from recent interviews with children and adolescents who have been blind from birth suggest that they do not know the forms of the simplest conventional gestures (e.g., "be quiet," "give me"); Iverson, 1996).

children were blind from birth and had some light perception but no functional vision. They came from low- to middle-class families, had no other known cognitive or neurological impairments, and attended age-appropriate public educational programs in the Chicago area that combined mainstreaming with additional work designed for visually impaired students. Three of the blind children attended the same school; the 4th child attended a public school in a different part of the city.

Twenty normally developing sighted children ranging in age from 10 years 3 months to 11 years 4 months also participated in the study. The sighted children (10 boys and 10 girls) were selected randomly from a fifth-grade classroom at the school attended by 3 of the blind children. Sighted children were randomly assigned to one of two conditions (blindfolded, sighted) with the constraint that each group contained an equal number of boys and girls. Children in the blindfolded group (mean age = 10 years 8 months) wore a blindfold throughout the session, and children in the sighted condition (mean age = 10 years 9 months) were permitted to use normal vision.

Tasks and Materials

Narrative task. The first task used a short audiotaped story set in a small town. Prior to story presentation, a model of the town was available, and children were encouraged to explore it. The story involved a small clock who had decided that he no longer liked his ticking sound. The plot focused on the clock's adventures (rolling over a bumpy road, crashing into the side of a movie theater, climbing a church tower) following his decision to run away from the clockmaker's shop to find a better sound. The model of the town was constructed on a board covered with self-sticking linoleum tile measuring approximately 4 × 4 ft. (1.2 × 1.2 m). Three strips of the board, approximately 3 in. (7.6 cm) wide, were left uncovered to serve as streets. One strip ran the width of the board and two ran the length, thus creating an H-shaped cross-street formation. The streets divided the town into six blocks onto which model railroad-size buildings (two houses, a movie theater, a church, and a train station) were placed.

Directions task. The children's classroom teachers were asked to generate a list of six different locations in the school building that were frequently visited by their students. Because the blind and sighted children's classrooms were on different floors of the school building and because 1 blind child attended another school, these places varied somewhat across groups, as did the routes used to travel to the locations.² Locations selected by the teachers included the office, the lunchroom, the restroom, the playground, the gym, homerooms, and the assembly hall.

Conservation tasks. Eight Piagetian conservation tasks (two continuous quantity, two length, two number, and two mass) were utilized with stimulus materials adapted for blind children. In the continuous quantity tasks, salt was substituted for water in order to make levels in the containers more salient to blind children. Stimuli for the conservation of length and number tasks were backed with Velcro and mounted on a 2 × 2 ft. (0.61 × 0.61 m) board covered with felt to reduce object movement during children's manual exploration of the materials. Two rulers covered with several layers of opaque masking tape served as stimuli for conservation of length, and a set of 12 fuzzy pom-pom balls was substituted for checkers in the number tasks. Two equal-sized balls of Playdoh were used in the conservation of mass tasks.

Procedure

Children were seen in their schools in a quiet room away from classroom activity. Each session lasted approximately 30 min and was videotaped. Children were escorted to the testing room and seated across the table from the experimenter. Those assigned to the blindfolded condition were asked if they would mind wearing a blindfold over their eyes during

the session and were told that they could remove the blindfold at any time if it became uncomfortable; all of the children in this condition agreed and none removed the blindfold during the course of the study.

Once children appeared comfortable with the setting, the experimenter introduced the town layout (which was on the table) by saying, "This is a little town, and I'm going to tell you a little bit about it right now. Then you'll hear a short story that takes place in the town." All of the children were given approximately 5 min to examine the model either visually (for children in the sighted condition) or manually (for blind and blindfolded children) while the experimenter provided verbal descriptions of the objects on the layout. At the conclusion of the exploration period, the children were asked several simple probe questions (e.g., "Can you show me where the church is?") to ensure that they were familiar with the layout of the town.

The story, which was audiotaped, was then played for the child. Children were told that they would also hear sound effects that went with the actions occurring in the story. A ticking clock was moved around the model to reproduce the path taken by the clock in the story, and bumps and crashes were produced by hitting a block of wood against the corresponding part of the layout.

At the end of the story, the model was removed and the children were informed that they were going to be introduced to a friend of the experimenter who had never been to the school before and needed directions to a few different places in the school building. The interlocutor entered the room and was introduced to the child, and children were then asked to give the interlocutor directions from their classroom to each of the six different locations provided by the teacher. Locations were presented in random order.

Following completion of the directions task, children were told that the interlocutor had never heard the story that had just been played for them. They were then asked to retell the story to the interlocutor as best they could remember it.

Finally, the experimenter presented the eight conservation tasks to all children in the following fixed order: two continuous quantity tasks, two length tasks, two number tasks, and two mass tasks. Each task consisted of three phases: (a) initial equality, (b) transformation, and (c) final equality. For example, in the initial equality phase of the first continuous quantity task, two identical tall, round containers filled with salt were placed in front of the child, and the child was asked to verify that the two containers held the same amount of salt. In the transformation phase, salt was poured from one of the tall containers to a short container placed in front of the child. Blind and blindfolded children were asked to keep their hands over the experimenter's hands during this transformation and all subsequent transformation phases. The child was then asked two questions: (a) the judgment question, "Do the two containers have the same or different amounts of salt in them?" and (b) the explanation question, "How can you tell?" or "How do you know?" In the final equality phase, salt from the short container was poured back into the original tall container and the child was again asked if the two containers had the same or different amounts of salt. A similar procedure was followed for the remaining seven tasks, which involved different transformations. After the child had answered the final question of the second mass task, he or she was thanked for participating in the study and was escorted back to the classroom.

Coding Speech and Gesture in the Three Tasks

Children's spoken and gestured responses to the tasks were transcribed from the videotapes. Hand movements were classified as gestures

² Although there was some variability in the routes that blind and sighted children were asked to describe, it is important to note that there were no systematic differences across groups in the complexity of these routes. The blind children described routes that involved as many different components as those described by the sighted groups.

only when they had an identifiable beginning and a clear end. Instances of object manipulation were not coded as gestures. These criteria were used to reduce the possibility of classifying instances of manual exploration in blind and blindfolded children as gestures and to make a distinction between ongoing hand movements and potential gestures in blind children.³ In addition, in light of McNeill's (1992) observation that 90% of all spontaneous gestures produced by sighted individuals occur while the speaker is actually talking, we considered a hand movement to be a gesture only if it was part of the speaking event and either preceded, co-occurred with, or followed speech. These relatively conservative criteria were used to avoid inflating the number of gestures included in our analyses.

To assess speech and gesture production on each task, we first calculated the total number of words and the total number of gestures produced by each child on the three tasks. For each task, we also described the form of each gesture in terms of the shape of the moving hand and the trajectory of the hand motion. Handshapes were coded according to a system designed for describing hand forms in American Sign Language (cf. Wilbur, 1987), and motions were coded according to the path, direction, and shape of the movement observed (e.g., no motion, up-down motion, arced motion). The specific coding procedures used for each of the three tasks are described below.

Narrative task. The story told to the children involved 20 events. Each child's narrative was scored in terms of the number of events the child conveyed in speech or in gesture. Children received credit for retelling an event in speech if they mentioned any aspect of that event (e.g., a child says "he fell" when talking about the clock jumping off the roof of the building). Similarly, children received credit for gesturing about a given event if they produced a gesture that portrayed any aspect of that event (e.g., a child makes a circling motion with an index finger pointing upward when talking about the clock climbing the spiral staircase).

Directions task. Target routes to each location were identified using a floor plan of the school buildings. Each route was then broken down into a series of steps. A *step* was defined as motion in a particular direction, with a new step beginning each time the route required a change in direction (either left-right or up-down). For example, the route from the classroom to the office consisted of five different steps: (a) going out the door and turning left, (b) going straight down the hall, (c) turning right into the staircase, (d) going down the staircase, and (e) turning left into the hallway to find the door to the office on the left. Most routes were found to consist of five steps, but there were some instances of three- or four-step routes.⁴

We then calculated the number of steps described in speech and in gesture for each route. Children were given credit for describing a step in speech if they mentioned any portion of that step (e.g., "You'll see the office" for Step 5 above) and for describing a step in gesture if they produced a gesture that portrayed any part of that step (e.g., making a left turn motion with a flat hand for Step 5 above). The number of steps described in speech and in gesture was then compared with the total number of possible steps for that particular route.

Conservation task. We first calculated the number of "same" responses that children produced in response to the judgment question ("Do the two containers have the same or different amounts of salt in them?") on each of the eight tasks. We then coded the gestured and spoken responses that children gave in response to the explanation question ("How can you tell?"), using a system developed by Church and Goldin-Meadow (1986). Spoken and gestured responses were broadly classified into one of three categories. *Equivalent* rationales expressed the belief that the altered object was not different in length, number, quantity, or mass despite its physical transformation (e.g., "They're still the same because you didn't add anything or take away anything"). *Nonequivalent* rationales expressed the belief that the altered object had indeed changed in length, number, quantity, or mass after the transforma-

tion (e.g., "That stick is longer now"). *Noncomparative* rationales did not compare the altered object to its prior state and merely referred to a characteristic of the object (e.g., "Because it's Playdoh"). Detailed descriptions of the particular types of explanations produced in gesture and in speech are presented in the Results section.

Coding reliability. Reliability was assessed by having a second coder independently transcribe and categorize a portion of the videotaped data. Agreement between two independent coders was 99% ($N = 15,436$) for identifying words, 95% ($N = 188$) for identifying gestures, and 89% ($N = 289$) for describing the handshape and motion forms of the gestures on all three tasks; 95% ($N = 209$) for identifying events retold in speech and 93% ($N = 30$) for identifying events retold in gesture on the narrative task; 92% ($N = 243$) for identifying steps described in speech and 91% ($N = 143$) for identifying steps described in gesture on the directions task; and 93% ($N = 264$) for assigning rationales to the spoken responses and 92% ($N = 164$) for assigning rationales to the gestured responses on the conservation task.⁵

Statistical analyses. Given the small number of blind children in our sample, all statistical analyses were nonparametric (Siegel, 1956) and involved two-tailed comparisons. To maximize statistical power in evaluating the blind versus sighted hypotheses most central to the study and to make use of orthogonal comparisons, we first contrasted sighted and blindfolded (sighted) children's performance on each task. If no significant difference existed between these groups, blindfolded and sighted children were then collapsed into a single comparison group and the performance of the blind children was compared with this combined group.

Results

Speaking and Gesturing in the Three Tasks

We begin by assessing the amount of speech and gesture elicited by each of the three tasks. Figure 1 presents the mean number of words that children in each of the three groups produced in the narrative, directions, and conservation tasks. Sighted and blindfolded children did not differ significantly in the number of words produced on any of the three tasks ($U = 25.5$, *ns*, in the narrative task; $U = 42.5$, *ns*, in the directions task; and $U = 49.0$, *ns*, in the conservation task). Data for the two sighted groups were subsequently collapsed and compared with the blind children's data. The blind children produced significantly more words on each of the three tasks than did the combined sighted groups ($U = 3.0$, $p < .004$, in the narrative task; $U = 1.0$, $p < .002$, in the directions task; and $U = 7.0$, $p < .01$, in the conservation task).

³ Other studies (e.g., Blass et al., 1974) have highlighted the presence of continuous motor activity during encoding tasks and significantly higher amounts of small, constant finger and hand movements in blind relative to sighted participants. Although this activity appears to serve an important function for blind individuals, the analysis of such movements in these blind participants is left to a future investigation.

⁴ Although a single target route was identified for each location, some children chose to describe an equally acceptable alternative route. In these cases, the route was analyzed in the same manner and the child's performance was examined relative to the number of possible steps in the alternate route.

⁵ Reliability for assigning rationales to both spoken and gestured responses on the conservation task was calculated in terms of the 10 categories displayed in Table 1 rather than three larger categories, non-comparative, nonequivalent, and equivalent.

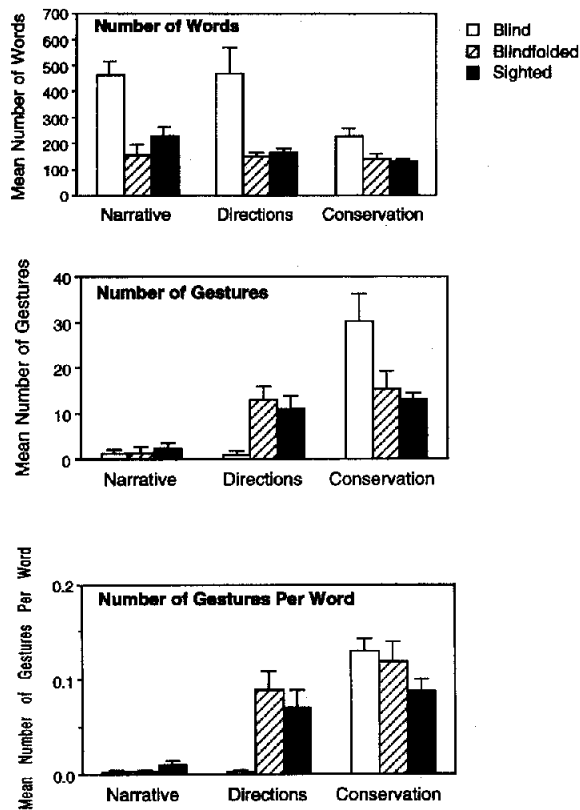


Figure 1. Mean number of words, gestures, and gestures per word produced by blind, blindfolded, and sighted children in each of the three tasks (the narrative task, the directions task, and the conservation task). The bars represent standard errors.

Thus, the blind children had no difficulty producing verbal responses on any of the three tasks and in fact spoke more than the sighted children on all of the tasks. We speculate that the blind children's speech may have been particularly prolific because they were unable to rely on the visual cues that are so often redundant with verbal information. As a result, they may have learned to make more efficient use of verbal memory and to rely on verbal information to a greater extent than sighted children (cf. Dekker & Koole, 1992).

We might further hypothesize that the blind children's extensive use of speech is complemented by an absence of gesture. If, for example, blind children do not gesture and rely on speech as their sole mode of communication, then they might need to increase the number of words they use to convey the same amount of information that sighted children convey using both gesture and speech; that is, blind children might produce a great deal of speech to compensate for their lack of gesture.

This hypothesis is not supported by the data. As is evident in Figure 1, even though the blind children consistently produced more speech than the sighted children, they did not necessarily produce fewer gestures. Figure 1 presents the mean number of gestures and the mean number of gestures per word, respectively, produced by the three groups of children on each task. As is evident, the blind children did gesture. Moreover, gesture pro-

duction revealed an interaction between participant group and task. While gesture production was low for each group in the narrative task ($U = 35.5$, *ns*, comparing the blind children with the combined sighted children), it increased sharply for all groups in the conservation tasks. Indeed, when we consider the absolute number of gestures produced, the blind children gestured more than the sighted and the blindfolded children on the conservation task ($U = 6.0$, $p < .01$, comparing the blind children with the combined sighted children). However, when we evaluated the relationship between gesture and speech and control for differences in overall production by calculating the number of gestures produced per word, this difference disappeared ($U = 17.5$, *ns*, comparing the blind children with the combined sighted children).

In contrast, there was a marked difference in gesture production among the groups on the directions task—the sighted and blindfolded children gestured extensively, while the blind children gestured rarely, if at all. There were no differences between the sighted and the blindfolded groups ($U = 42.0$, *ns*, for absolute number of gestures produced; $U = 37.5$, *ns*, for number of gestures produced per word) but significant differences were observed between the combined groups of sighted children and the blind children, both with respect to absolute number of gestures produced ($U = 14.5$, $p < .05$) and in number of gestures produced per word ($U = 13.0$, $p < .05$).

The grouped data in Figure 1 suggest that if a given child is going to gesture, that child will be most likely to gesture on the conservation task, somewhat less likely to gesture on the directions task, and least likely to gesture on the narrative task. Individual data confirm this prediction. All 20 of the sighted children exhibited the pattern inferred on the basis of the grouped data: 4 children (2 sighted, 2 blindfolded) gestured only on the conservation task, 10 (3 sighted, 7 blindfolded) gestured on both the conservation and the directions tasks, and 6 (5 sighted, 1 blindfolded) gestured on all three tasks.⁶ Three of the 4 blind children also conformed to the pattern: 1 gestured on only the conservation task, 1 gestured on both the conservation and directions tasks, and 1 gestured on all three tasks. However, the 4th blind child gestured in the conservation and narrative tasks but not in the directions task, suggesting that gesturing in the directions task is not as robust in blind children as it is in sighted children.

In summary, blind children do gesture. However, they do not gesture in all of the contexts that sighted children do. To explore the nature of this finding, we next examined children's performance on each of the three tasks, focusing particularly on the type of information conveyed in gesture versus speech. We begin with the task that yielded relatively few gestures in any group (the narrative task); we then turn to the task on which all of the children gestured (the conservation task); and we conclude with the task on which sighted children gestured frequently but blind children did not (the directions task).

⁶ No sex differences in gesture production were observed among sighted children. Approximately the same number of boys and girls were found to demonstrate each of the three distributions described in the text.

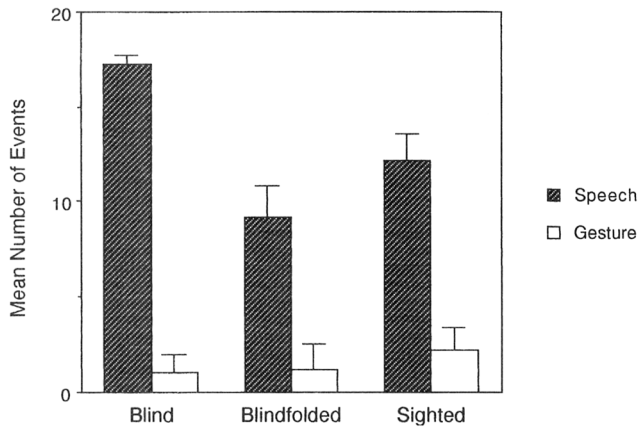


Figure 2. Mean number of events produced by blind, blindfolded, and sighted children in speech and in gesture on the narrative task. The bars represent standard errors.

The Narrative Task

Total number of events conveyed. To assess children's performance on the narrative task, we first determined the total number of story events (out of a possible 20) included in each child's retelling. For this analysis, we gave children credit for an event if it was mentioned in speech, in gesture, or in both modalities. We found that children in all three groups did quite well in recalling story events, but that blind children included significantly more events in their narratives than did sighted children. On average, sighted children included 12.6 events in their narratives and the blindfolded children included 9.2 events, a difference that was not reliable ($U = 30.5, ns$). In contrast, the blind children included a mean number of 17.3 events in their retellings, significantly more than the 10.7 events that the combined sighted groups included in their narratives ($U = 6.5, p < .01$).

Events conveyed in speech versus gesture. We next explored the modality in which events were described. The mean number of events conveyed in speech and in gesture by children in each of the three groups is presented in Figure 2. Not surprisingly, given the data in Figures 1B and 1C, children in all groups conveyed very few events in gesture. Moreover, all of the events that were conveyed in gesture were also conveyed in speech. In other words, the gestures produced on this task conveyed no new information beyond that conveyed in speech (note that this also means that the number of events conveyed in speech and displayed in Figure 2 was identical to the total number of events included in the narratives that was reported in the preceding paragraph).

We then asked whether the blind children conveyed the same story events in gesture as did the sighted children. As a group, the sighted children conveyed 12 of the 20 events of the story in gesture, while the blind children conveyed only 4—a result that is not surprising given the small size of our blind sample relative to the size of the sighted sample. However, all four of the events that the blind children conveyed in gesture were also conveyed in gesture by at least one sighted child. Thus, the set

of events that the blind children conveyed in gesture fit within the range of events conveyed in gesture by the sighted children.

With respect to the types of gestures observed in this task, children in all three groups produced iconic gestures that reproduced a physical aspect of the scene described in speech (cf. McNeill, 1992). For example, one sighted child made a spiral motion with his index finger pointing upward while saying, "And he went up a winding staircase." In addition, the sighted children also produced a very small number of metaphoric gestures that they used to introduce a character or a situation (cf. McNeill, 1992). For instance, a sighted child extended both hands, palms upward, in front of her body as though presenting something while saying "There was a little clock."

Gesture form. Finally, we asked whether the gestures produced by the blind children took the same form as the sighted children's gestures. Because so few gestures were produced on the narrative task, this analysis was necessarily anecdotal. We selected an event in the story that at least 1 child in each of the three groups had conveyed in gesture and compared the gestures for that event in terms of handshape and motion. A blind child, a blindfolded child, and a sighted child all used gesture when describing the event in which the clock bumped into a wall of a building. All 3 children used the same handshape (a palm handshape with the fingers spread, although the sighted children spread all four fingers and the thumb while the blind child extended only the thumb) and the same motion (a movement away from the body).

Of the 3 children, the blind child's gesture was the most elaborate—he used both hands, with a flat palm handshape, and moved his right hand (representing the clock) away from his body to hit his left hand (representing the wall). Both of the sighted children used a single hand with a flat palm handshape and moved that hand (representing the clock) away from their bodies. In short, the blind child's gesture was strikingly similar to those of the 2 sighted children. We return to this issue in our analyses of the conservation task, in which children in all three groups gestured extensively.

The Conservation Task

Responses to the judgment question. To assess children's performance on the conservation task, we first determined how many *same* responses the children in each group gave in response to the judgment question. Recall that a *same* response reflects the accurate belief that the transformed object has not changed in quantity despite its changed physical appearance. On average, the blind children gave 4.8 *same* responses (out of 8), the blindfolded children gave 5.7, and the sighted children gave 6.6. Blind children have previously been reported to be somewhat delayed in their mastery of conservation (Gottesman, 1973; Hatwell, 1966/1985; Ochaita & Rosa, 1988; but see Cromer, 1973, for evidence against this claim); thus, the fact that they produced fewer *same* responses than the sighted children may not be particularly surprising (although this difference was not significant, $U = 11.9, ns$). More interesting, however, is the fact that the blindfolded children also produced fewer *same* responses than the sighted children (although this difference was also not significant, $U = 36.0, ns$). It may be that the absence of visual cues (even if only temporary) makes it more

difficult for a child to recognize that the quantity in each of these tasks is not affected by the transformation—a hypothesis that we are currently testing by asking the same sighted children to respond to the conservation tasks both with and without a blindfold.

Responses to the explanation question. We next examined the children's responses to the explanation question. Recall that both spoken and gestural explanations were broadly classified as noncomparative, nonequivalent, or equivalent. The particular types of rationales produced within each of these larger categories and examples of both the spoken and the gestured form of each rationale are displayed in Table 1.

The children produced two types of noncomparative explanations: (a) explanations describing a single or multiple attributes on only one of the task objects, all of which are irrelevant to the quantity under consideration (descriptor), and (b) explanations indicating the task objects with no further elaboration (indicator).

In addition, the children produced two different types of non-equivalent explanations: (a) explanations comparing the task objects on a single dimension along which the two objects differed (comparison), and (b) explanations stating that a transformation had been performed without noting that the action could be reversed (transformation).

Finally, the children produced six different types of equivalent explanations: (a) explanations focusing on the fact that the experimenter merely moved or rearranged the object and thus did not alter its quantity (all-you-did); (b) explanations arguing that the transformed object has the same quantity as it did initially because variation from the original state on one dimension is compensated for by variation on a second dimension (com-

pensation); (c) explanations arguing that the transformed object is still the same quantity because it can be paired in a one-to-one fashion with the unchanged object (one-to-one correspondence); (d) explanations stating that although the transformed and original quantities differ along the altered dimension, the relevant dimension on which to compare the objects (e.g., length, as opposed to orientation or placement of the sticks) has remained unchanged (identity); (e) explanations arguing that the quantity is the same because the experimenter neither added to nor subtracted from the original quantity (add-subtract); and (f) explanations stating that reversing the transformation can return the transformed stimulus to its original state and therefore the quantity has not changed (reversibility).

Explanations in speech versus gesture. Table 2 presents the proportion of explanations of each type produced in speech and in gesture averaged across children in each of the three groups. As is evident, for both speech and gesture, each cell that is filled for the blind children is also filled for the sighted children. In other words, the blind children's performance on this task is comparable in both modalities to the performance of sighted children on the same task.

Focusing first on the content of the children's spoken explanations, we can see that, with few exceptions, the blind children gave the same types of explanations as the sighted children with approximately the same frequency. The most apparent difference across the groups is that sighted children produced more equivalent explanations and fewer nonequivalent explanations than either the blind or the blindfolded children—a result that is not surprising given the larger number of *same* responses produced by sighted children relative to the other two groups.

Turning next to the content of the children's gestured explana-

Table 1
Examples of Spoken and Gestured Explanations Produced on the Conservation Task

Type of explanation	Speech	Gesture
Noncomparative		
Descriptor	"Because it's a stick"	Point to the unchanged stick
Indicator	"Because it's tall"	Point to top edge of unchanged container, indicating its height
Nonequivalent		
Comparison	"This one's a line and this one's a circle"	Point at each of the endpoints of the unchanged row of balls, followed by a point circling over the balls arranged in a circle
Transformation	"They're different because you rolled it"	B hand rolled over the sausage-shaped ball of clay
Equivalent		
All-you-did	"All you did was move it"	Mimes moving the checkers, followed by a shrug and a two-handed flip
Compensation	"This container is shorter than this one but it's also wider"	Point to the height of the transformed and then the untransformed stick, followed by points at the widths of each container
One-to-one correspondence	"The balls in this row match up with the balls in that row"	Point moving from the balls in Row 1 to the corresponding balls in Row 2
Identity	"These two sticks are the same length"	2 B hands placed at each of the endpoints of the transformed stick, followed by the same gesture on the endpoints of the unchanged stick
Add-subtract	"They're still the same number because you didn't take any away or add any"	Mimes removing a ball from the transformed row
Reversibility	"When I put it back it would be the same number"	2 C hands mime squishing balls back together or forming them back into a line

Note. The children in our study did not produce instances of all of the equivalent explanations in gesture (cf. Table 2). Examples of these gestural explanations are taken from previous work by Church and Goldin-Meadow (1986) and from ongoing work on conservation.

Table 2
Explanations Produced by the Three Groups on the Conservation Task in Speech and in Gesture

Type of explanation	Explanations produced in speech			Explanations produced in gesture		
	Blind	Blindfolded	Sighted	Blind	Blindfolded	Sighted
Noncomparative						
Descriptor	.09	.11	.13	.32	.21	.29
Indicator		.04		.47	.28	.41
Nonequivalent						
Comparison	.30	.29	.11	.17	.15	.08
Transformation	.23	.10	.10	.01	.13	.19
Equivalent						
All-you-did	.03	.19	.22			
Compensation	.03	.01	.01		.01	.01
One-to-one correspondence			.01			
Identity	.24	.24	.32	.03	.11	
Add-subtract	.08	.01	.09			.01
Reversibility			.01		.10	.01

Note. The numbers in the table were calculated by taking the number of spoken (or gestural) explanations of each type that a child produced as a proportion of the total number of spoken (or gestural) explanations that the child produced and then averaging those proportions across all of the children within each of the three groups. The point of this table is that, for both speech and gesture, when there is an entry in a cell for the blind children, there is also an entry in the comparable cell for the sighted children, and in roughly the same proportion.

tions, we find that the three groups of children again produced the same types of explanations in approximately the same distribution (see Table 2). However, two interesting differences between groups were apparent. First, blindfolded children overall produced a higher proportion of equivalent responses in gesture relative to blind and sighted children (.22 vs. .03 and .03, respectively). Second, looking within the equivalent response category, a trade-off between speech and gesture for blind children was evident in their production of the transformation explanation. While sighted and blindfolded children tended to produce the transformation response in speech and gesture in roughly equal proportions, blind children produced this response almost exclusively in speech.

To determine how fine-grained the similarities between the groups were, we examined the particular dimensions of the task objects that the children described in gesture in their descriptor and comparison explanations. We found that blind children conveyed precisely the same dimensions in gesture as did sighted children—area, shape, height, length, placement, intersection of sticks, shape, and orientation.⁷ Thus, the blind children used their gestures to convey the same information about the dimensions of conservation that the sighted children represented in their gestures.

The relationship between gesture and speech within a response. By definition, the gestures that children produced on both the narrative and the conservation tasks always occurred with speech. However, unlike the narrative task, in which gesture always conveyed the same information as speech, the gestures produced in the conservation task occasionally conveyed information that was different from the information conveyed in the accompanying speech. For example, in the continuous quantity task, one child indicated the height of one of the containers in gesture (she placed a palm handshape at the salt level of the glass) but described the width of the container in speech (“This one’s skinny”). On average, the blind children produced 11.2 explanations that contained both speech and gesture, the blind-

folded children produced 6.1, and the sighted children produced 5.9. Children in all three groups used their gestures to convey information that did not appear in their speech. The blind children conveyed different information in their gestures than they did in speech in an average of .03 of their gesture-speech combinations, and the blindfolded and sighted children did so in .22 and .05 of their gesture-speech combinations, respectively.⁸

Why might the blindfolded children have produced proportionately more explanations in which gesture conveyed different information from speech? Explanations of this sort have previously been observed in conservation and other reasoning tasks and labeled *mismatches* (Church & Goldin-Meadow, 1986). Moreover, a relatively large proportion of mismatches in a child’s explanation of a task has been found to signal the fact that the child is in a cognitively unstable or uncertain state with respect to that task (Alibali & Goldin-Meadow, 1993; Church &

⁷ The only difference in dimensions conveyed came from the blindfolded children. On the conservation of continuous quantity task, the blindfolded children occasionally mentioned the weights of the containers in speech and, in gesture, held two flat hands with the palms up as though comparing the weights of the two containers. Temporary loss of sight seemed to encourage the children to explore a new dimension of comparison—a dimension that did not appear to be salient either to the children who could see this particular task, or to the children who had never seen this or any other task.

⁸ We followed Church and Goldin-Meadow (1986) in deciding when gesture conveyed different information from speech. If the information conveyed in gesture was a subset of the information conveyed in speech, it was not considered different (e.g., the child referred to the heights of both containers in speech, “This one’s tall and this one’s short,” but indicated the height of only the tall one in gesture). In order for the information conveyed in gesture to be considered different from speech, gesture had to convey additional information not found anywhere in the accompanying speech (e.g., the child referred to the transformation in speech, “You poured it,” but indicated the width of the container in gesture).

Goldin-Meadow, 1986; Perry, Church, & Goldin-Meadow, 1988, 1992). The temporary lack of access to visual cues that the blindfolded children experienced in our study may have made the already difficult conservation task even more confusing for them and, as a result, may have increased both their uncertainty about the task and their production of mismatches.

Gesture form. All of the gestures that the children produced on the conservation task were iconic. Table 3 lists the different types of handshape and motion forms exhibited in these iconic gestures, along with the mean proportion of gestures that incorporated these forms in each of the three groups. As in Table 2, the point here is that the gestures of the blind and sighted children resembled each other both quantitatively and qualitatively.

First, with respect to handshape, it is evident that with the exception of a few instances of the A handshape (hand shaped in a fist), the blind children produced forms that fell within the range of forms used by the sighted children. Both blind and sighted children used handshapes that did not involve finger extension and followed the natural configuration of the hand: a curved palm in the shape of a C (the C hand) or O (the O hand), and a flat palm with fingers together (the B hand) or spread (the 5 hand). In addition, blind and sighted children occasionally used other handshapes involving the extension of individual fingers (e.g., a Y hand with the thumb and pinky fingers extended and the remaining fingers bent toward the palm). Finally, sighted (but not blind or blindfolded) children made frequent use of the pointing hand— .63 of the sighted

children's gestures contained the pointing hand, compared to only .02 for the blind and .10 for the blindfolded.

Second, with respect to motion, we see that blind and sighted children moved their hands in similar ways when they gestured (see Table 3). The children in all three groups frequently held their handshapes in place and produced no motion at all or used a back and forth sweeping motion. In addition, the blind children frequently used a patting motion (a motion used on occasion by blindfolded but not by sighted children), and the blindfolded and sighted children frequently used a circular motion (a motion the blind children used on occasion). The remaining motions (up and down, side to side, arc, trace, poke, pinch) were not used frequently by any of the three groups. Most important, however, is that there were no instances of a motion used by a blind child that was not also used by a sighted or blindfolded child. Thus, the blind children produced gestures whose forms fell within the range of forms found in the sighted children's gestures.

Finally, to examine the extent to which the handshape-motion combinations used by the blind children resembled those of the sighted children, we listed the particular handshape-motion combinations produced by all of the sighted children in the study (including the blindfolded children). We then determined how many of the blind children's handshape-motion combinations fell within this set. We found that 95% (18 of 19), 91% (43 of 47), 89% (25 of 28), and 75% (30 of 40), respectively, of the total number of handshape-motion combinations that each of the 4 blind children produced were combinations that had been produced by sighted children in our sample. In other words, the blind children produced their handshapes and motions in combinations that, for the most part, had been observed in the gestures of the sighted children.

In sum, despite the fact that the blind children had never seen the gestures of other speakers, the gestures they produced on the conservation task were remarkably similar in content and form to those of sighted children. Recall, however, that the blind children did not gesture in all task contexts. We turn now to our final task, in which the blind children gestured very little and the sighted children gestured frequently.

The Directions Task

Total proportion of steps conveyed. To assess children's performance on the directions task, we calculated the proportion of steps that each child described (out of the total number of steps possible for that route) and averaged those proportions across children in each group. On the whole, the children were quite good at recounting the steps that were necessary to describe a particular route. The sighted and blindfolded children described .70 and .72 of the possible steps respectively and did not differ significantly in the proportion of steps they described ($U = 44.0, n.s.$). The blind children described .87 of the possible steps and, although this proportion was somewhat larger than the combined sighted children's proportion (.71), the difference was not statistically reliable ($U = 17.5, p < .08$).

Steps conveyed in speech versus gesture. We next examined the modality in which the children produced each of the steps in their descriptions. Figure 3 presents the mean proportion of events conveyed in speech and in gesture by children in each

Table 3
Handshapes and Motions in the Gestures Produced by the Three Groups on the Conservation Task

Gesture form	Blind	Blindfolded	Sighted
Handshape			
C hand	.05	.08	.10
O hand	.03	.01	.00
B hand	.23	.45	.14
5 hand	.64	.36	.11
A hand	.02		
Pointing hand	.02	.10	.63
Y hand	.01		.01
V hand			.01
Motions			
No motion	.36	.58	.65
Back and forth sweep	.22	.12	.13
Pat in place	.35	.05	
Circular motion	.01	.12	.10
Up and down motion	.02	.04	.04
Side-to-side motion	.03	.04	.03
Trace shape of object	.01	.02	
Poking motion	.01	.01	
Arced motion		.02	.04
Pinching motion			.01

Note. The numbers in the table were calculated by taking the number of handshapes (or motions) of each type that a child produced as a proportion of the total number of handshapes (or motions) that the child produced and then averaging those proportions across all of the children within each of the three groups. The point of this table is that for the most part, when there is an entry in a cell for the blind children, there is also an entry in the comparable cell for the sighted children, and in roughly the same proportion.

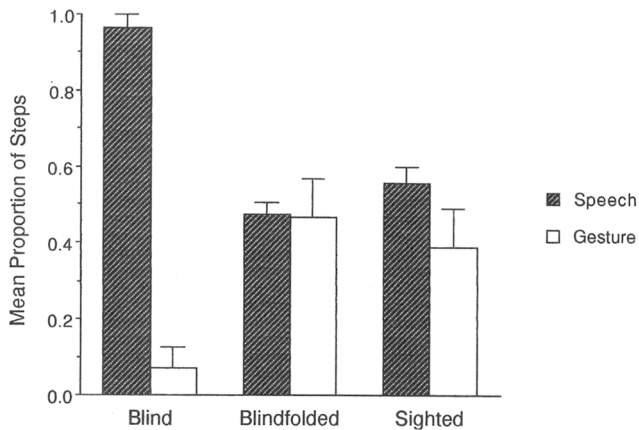


Figure 3. Mean proportion of steps produced by blind, blindfolded, and sighted children in speech and in gesture on the directions task. The bars represent standard errors.

of the three groups. Focusing first on steps conveyed in speech, we see that sighted and blindfolded children both produced approximately half of their possible steps in speech (.56 vs. .47, $U = 31.5$, *ns*). In contrast, the blind children produced .96 of their possible steps in speech, significantly more than the .52 produced by the combined sighted groups ($U = 0.0$, $p < .002$). This pattern was reversed for gesture. The sighted and the blindfolded children both produced almost half of their steps in gesture (.38 vs. .46, $U = 46.0$, *ns*). However, the blind children produced only .07 of their possible steps in gesture, significantly less than the .42 produced by the combined sighted groups ($U = 16.0$, $p < .06$). Moreover, only 2 of the 4 blind children contributed to this value, together producing a total of only four gestures on the directions task. Thus, the blind children relied almost exclusively on speech to convey their route descriptions, while the sighted children made roughly equal use of both modalities.

The relationship between gesture and speech within a response. Given that the sighted children used gesture so frequently, we next asked whether they used their gestures to convey the same or different information as they conveyed in their speech. On average, the sighted children produced 12.1 responses that contained both speech and gesture and the blindfolded children produced 15.8. The sighted children conveyed different information in gesture than they did in speech in .51 of these gesture–speech combinations, and the blindfolded children did so in .67 of their gesture–speech combinations.⁹ In some of these responses, the child actually conveyed two distinct steps, one in speech and a second one in gesture. For example, one sighted child indicated the initial step in a route in gesture (she moved a B hand toward the left, indicating that the first move was to go left after leaving the classroom) while at the same time describing the second step in the route in speech (“Take the stairs”). In other responses, sighted children described the same step in both gesture and speech but mentioned different components of the step in the two modalities. For example, one child said, “You go like this and there’s the doors,” while explicitly describing the particular path to be taken in gesture (he pointed straight ahead and then made a U-

turn motion with a B hand). A similar instance was observed in another child, who said, “And then you’ll be at the assembly hall,” while gesturing toward her left side with a B hand.

The 2 blind children who produced gestures on this task produced a total of only four gesture–speech combinations. In all of these combinations, they used gesture to convey the same information as they conveyed in speech.

Gesture form. The sighted children’s gestures consisted primarily of a pointing hand or a B hand, usually with the palm facing down. Gesture motions reproduced the direction of the path being described, with either an extension of the arm to indicate “straight ahead” (e.g., a point with the arm extended in front of the body) or a bend of the wrist to show the direction of a turn (e.g., a point with the wrist bent so that the extended index finger indicated toward the child’s left). As noted above, although only 2 of the blind children produced gestures on this task, their gestures were similar to those produced by sighted children (e.g., a B hand with the wrist bent to indicate a turn to the left). The single, interesting exception is that no instances of pointing were ever observed in the blind children’s gestures.

Why didn’t the blind children gesture on the directions task? We have shown that, for the sighted children, gesture played a large role in conveying essential information in the directions task. The question is why gesture did not play this role for the blind children. If, as McNeill (1992) suggests, gesture and speech form a single system of communication based on a common cognitive representation, the striking group differences in use of gesture on the directions task might lead us to expect group differences in speech as well. One salient difference between the speech of the blind and sighted children was in their use of landmarks.¹⁰ The sighted and blindfolded children pro-

⁹ Note that the sighted children produced proportionately more gesture–speech combinations in which gesture conveyed different information than speech on the directions task than they did on the conservation task. Gesture–speech “mismatch,” when produced on a reasoning task, has been found to reflect cognitive instability with respect to that task (Alibali & Goldin-Meadow, 1993; Church & Goldin-Meadow, 1986; Perry et al., 1988). It is possible that mismatch on the directions task also reflects the child’s cognitive uncertainty, but here in terms of dealing with directions. With respect to the large proportion of mismatches in the directions task relative to the conservation task, it is worth noting that many of the children in the Church and Goldin-Meadow (1986) study produced mismatches in over 50% of their explanations on the conservation task. However, the children in the Church and Goldin-Meadow study tended to be younger and less knowledgeable about conservation (i.e., they produced fewer same judgments) than the children in our study. In other words, they were on a steeper part of the learning curve than the children studied here, and thus might have been expected to be more cognitively unstable in their knowledge of conservation and to produce more mismatches.

¹⁰ Two additional differences between the sighted and the blind children’s speech were noted. First, 6 of the sighted and 1 of the blindfolded children—but none of the blind children—described some of the target routes by relating them to paths that they had mentioned previously. For example, a sighted child who had already described the route to the office responded to the request for directions to the assembly hall by saying, “You go the way you went to the office, but this time you turn right instead of left.” This is an even more extreme example of the sighted children’s tendency to view paths in larger chunks than the blind children (see text). Second, in addition to relative terms such as left

duced relatively few landmarks in their spoken route descriptions (2.9 and 1.8, respectively; $U = 42.0$, *ns*). In sharp contrast, the blind children produced many more landmarks than did the sighted children (15.7 compared with 2.4 for the combined sighted groups, $U = 0.0$, $p < .002$). This difference was observed despite the fact that the blind children were describing routes in the same building as the sighted children and thus had the same opportunities to single out particular locations in their descriptions.

Moreover, landmarks tended to serve different functions for blind and sighted children. The sighted children used the few landmarks that they produced to locate a place or a turn. For example, when describing the route from the classroom to the bathroom, 1 sighted child used the staircase as a landmark to locate the turn: "Okay, there's one straight down there and when you get near the staircase you turn to the left, except it's a little bit before the staircase." On average, 85% of the blindfolded children's landmarks and 95% of the sighted children's landmarks were used for this locating function, compared with 2% for the blind children.

In contrast, the blind children used landmarks to break up a path into a series of small pieces that are navigable from a blind person's point of view. For example, to describe the path from the classroom to the gym, 1 blind child mentioned a series of landmarks that divided the path into a progression of locations: "Turn left, walk north, then you'll see the office, then you'll see 106, then 108, then 110, 112, then there's a doorway. Then there's a hall. You walk past the hallway. Then there'll be a girls' bathroom. And then it's [the gym] going to be on the right." On average, 98% of the blind children's landmarks functioned to break up a path into a progression of locations. Indeed, breaking up a path into a series of locations has been previously identified as a strategy commonly found in blind adults' route descriptions (Brambring, 1982). In our own directions task, 70% of the steps that the blind children described were broken up into a series of locations, compared with only 3% and 5% of the blindfolded and sighted children's steps, respectively.

Thus far, we have shown that the verbal descriptions produced by the blind and sighted children on the directions task differed greatly. Did these differences in speech complement the differences found in gesture? As described above, the sighted children reproduced the direction of the path in their gestures; they either extended their arms to indicate straight ahead, or they bent their wrists to indicate the direction of a turn. In other words, their gestures—like their speech—portrayed the path as a single unit. Given that gesture is by nature global and synthetic (McNeill, 1992), it appears to be an ideal medium for conveying a path when it is envisioned as a global whole. However, gesture ap-

pears less well-suited for representing a path when it is broken up into a series of locations. On this view, a possible explanation for the observed differences in gesture production is that the global representation underlying the sighted child's directions may be channeled into both speech and gesture, while the segmented representation underlying the blind child's directions may be channeled almost exclusively into speech.

What we are suggesting is that the group difference in gesture production lies not in the ability to produce gestures nor in the general ability to represent space (though this is a claim made by others; see Hartlage, 1969; Rieser, Lockman, & Pick, 1980). A potentially more interesting hypothesis is that the asymmetry in gesture production lies in qualitative differences in the content of path representations that are generated when children are asked to describe a route for another. In other words, blind and sighted children tend to generate qualitatively different representations of a path—global representations in sighted children and segmented representations in blind children—and it is this difference that leads to gesture in the sighted groups and not in the blind group.

From this hypothesis, we can generate two additional predictions. First, if our hypothesis is correct, we would expect that those sighted children who describe a path as a series of locations in speech (thus suggesting that they have represented that path in a segmented fashion as a blind child might) should be less likely to produce gestures than sighted children who never produce segmented descriptions in speech. Although most of the sighted children described paths as global wholes, 3 sighted children (2 in the blindfolded group and 1 in the sighted group) did, at times, break up their paths into a series of locations in speech. As predicted, these 3 sighted children produced gestures on only 31% of the steps they described—far less often than the 17 sighted children who never broke their paths into a series of locations in speech and who produced gestures on 75% of the steps they described. Moreover, when these 3 sighted children produced segmented paths, they never gestured on those paths, thus accounting for their relatively low gesture levels.

Second, we would also expect that on the occasions when the blind children gesture, their gestures should accompany paths described in speech as global wholes. Although only 2 blind children in our study produced gestures on the directions task, 84% of those gestures accompanied spoken descriptions that portrayed the path as a global whole (i.e., they accompanied descriptions of paths that had no landmarks and therefore were not broken into a series of locations) and only 16% accompanied spoken descriptions that portrayed the path as segmented. For sighted and blindfolded children, 100% and 98%, respectively, of their gestures were produced along with global path descriptions, while 0% and 2%, respectively, occurred with segmented descriptions.

These findings suggest that if a blind child represents a path as a sighted child typically does (i.e., as a global whole), that blind child will be likely to gesture. Conversely, if a sighted child represents a path as a blind child typically does (i.e., as a progression of locations), that sighted child will tend not to gesture. Thus, the representation that underlies a communication appears to be the essential factor in generating gesture within that communication, not the speaker's status as blind or sighted.

and right, 1 of the blind children—but none of the sighted children—made extensive use of absolute direction terms (north, south, east, and west) in his description of both locations and turn movements. Interestingly, this child was found to confuse east and west, much like the right-left confusions that the other children (blind and sighted) demonstrated. Although this difference might be linked to the difference in rate of gesturing found in the blind and sighted children, our guess is that it is not, in large part because only 1 of the blind children made use of absolute direction terms.

Discussion

In this study, we examined the gestures produced by children who have been blind since birth. These children have never seen gesture and cannot apprehend how a listener might benefit from gestures produced during communication. The study has three major findings. First, we found that despite their lack of visual experience with gesturing, the blind children in our sample produced spontaneous gestures as an accompaniment to speech. Second, the blind children used gestures to express the same information as sighted children, and their gestures took the same forms as those of sighted children. Finally, gesture use varied across task contexts in both blind and sighted children. Few of the children gestured on the narrative task, all of the children gestured on the conservation task, and a majority of sighted but few blind children gestured on the directions task. We consider each of these findings in turn.

Blind Children Do Gesture

Previous work on the use of nonverbal communication by adults who have been blind from birth has reported a virtual absence of gesture production in this population (e.g., Carroll, 1961; Manly, 1980; Sasaki, 1992). In contrast, we found that although the blind children in our study did not gesture in all contexts, they consistently produced gesture on one of our tasks, the conservation task. In fact, on this task, the blind children produced the same number of gestures per word as the sighted children, and more gestures in terms of absolute numbers. Thus, gesturing does occur in blind individuals, although not in all contexts that elicit gesture in sighted persons.

A substantial body of recent work has argued that the gestures that speakers produce with speech convey information, and that this information is accessible to listeners (Alibali et al., 1997; Goldin-Meadow et al., 1992; Goldin-Meadow et al., 1993; Goldin-Meadow & Sandhofer, 1996; Kendon, 1994; McNeill et al., 1994). However, even though gesture conveys information to the listener, it may not necessarily be produced with the intent to do so. At times, gesture may function for speakers themselves, reflecting their thoughts in a medium that happens to be relatively transparent to the listener. Because blind listeners cannot see gestures and thus do not have access to the information that gesture conveys, they do not experience the communicative function of gesture first-hand. If, as we have found in our study, blind speakers do gesture despite their lack of experience with gesture's communicative function, we can take this as evidence that gesture has a function for the speaker and not merely for the listener.

What role might gesture play for the speaker in the conservation task, the task that reliably elicited gesture in all of the children? The explanation question asked of all of the participants in the conservation task requires that the children examine the assumptions on which their beliefs about quantity are based. Up until the moment that the question is asked, these beliefs are likely to have been unexamined and unquestioned by the child, and are therefore relatively difficult to put into words. Gesture may help the child think through the problem by providing a medium for expressing relatively inarticulate thoughts. Conservation is also a concrete and spatial task, one whose

properties may be more easily expressed in the imagistic medium offered by gesture than in the linear and segmented medium provided by speech (cf. McNeill, 1992; Goldin-Meadow, McNeill, & Singleton, 1996).

Blind Children Use Gesture in the Same Ways Sighted Children Do

The content and form of gesture. Blind children cannot see the gestures produced by others. If the gestures that people see determine, at least in part, the content and form of the gestures they produce, then one might expect blind children's gestures to look different from those of sighted children. In fact, we found that all of the gestures produced by the blind children resembled sighted children's gestures in both content and form.

In terms of content, the blind children conveyed the same types of conservation rationales in gesture as did the sighted children. They even highlighted the same dimensions of comparison in their gestures as the sighted children, suggesting that tactile exploration of an object can give rise to similar kinds of knowledge about objects as visual exploration (cf. Kennedy, 1993). In addition, the blind children produced gestures for the same events (albeit a subset of those events) that the sighted children gestured about in their narratives, and, like the sighted children, the 2 blind children who gestured on the directions task tended to produce those gestures when they gave descriptions of an undivided path not broken up by landmarks. The blind children, in other words, used gesture to convey the same information as did the sighted children.

Moreover, like the sighted children, the blind children at times conveyed information in gesture that they did not convey in speech. On the conservation task, both the blind and sighted children gave explanations in which the rationale conveyed in gesture was different from that conveyed in speech. Thus, if a complete account of the blind child's understanding of conservation is the goal, paying attention to the child's gestures is essential—just as it is in assessing the sighted child's understanding of conservation.

In terms of gesture form, we again found remarkable similarity in the gestures of blind and sighted children. Our tasks were designed to elicit primarily iconic and deictic gestures, and they did so in both blind and sighted children. A small number of metaphoric gestures were also observed in a few of the sighted children on the narrative task. Given the small size of our blind sample, it is not surprising that we did not find metaphoric gestures in the blind children. However, these findings leave open the possibility that, although blind individuals may gesture, they may not produce metaphoric gestures—that is, gestures that are abstract in the way they depict a referent (e.g., a circling motion used to indicate continuous action).

The iconic gestures that the blind children produced resembled those of the sighted children in both motion and handshape. The set of motions that the blind children used on the conservation task was almost identical to the set used by the sighted children. Moreover, the set of handshapes that the blind children used on the conservation task was a subset of those used by the sighted children. It is also important to note that, like the sighted children's iconic gestures, most of the iconic gestures produced by the blind children on the conservation task involved touching

but not directly manipulating the task objects. The continued presence of concrete objects may have helped support gesture production in both blind and sighted children by providing an easy point of reference to anchor the child's explanations. These results leave open the possibility that blind children might not be able to gesture unless they have concrete props at their disposal. However, this possibility is somewhat unlikely given the fact that the blind children in our sample did produce a small number of gestures without props on the narrative and directions tasks.

The largest difference in form between the blind and sighted children's gestures was found in deictic gestures, or points. The almost total absence of the pointing handshape in the blind children is one of the most striking findings of this study. Points serve two functions: to indicate and to establish a visual "line of regard" for the benefit of both the pointer and the observer. Even though the blind children in our study did not use the pointing handshape with the index finger extended, many of their gestures did serve an indication function (the children typically used a B or 5 hand to indicate). Thus, the blind children's failure to point should not necessarily be taken as a failure to indicate.

We suggest that the absence of the pointing handshape in the blind children's repertoire is caused by the difficulty of establishing a visual line of regard. Visual line of regard is a line of reference that extends down the length of the arm in the direction of the index finger extension and has two endpoints: the pointer's eyes and the referent of the gesture. The observer determines the referent of the pointing gesture by following the length of the visual line of regard until the focus of the point is reached (Butterworth & Groer, 1990). The idea here is that line of regard is both established and interpreted visually. It may well be, therefore, that the absence of the pointing handshape in the blind children is an outgrowth of the fact that, in their case, vision cannot be used to set up the line between the pointer's eyes, the index finger, and the gestural referent. Consistent with this argument is the fact that the blindfolded children were far less likely than the sighted children to use the pointing handshape in the conservation tasks. Perhaps even temporary loss of vision in sighted persons may affect the ability to make use of line of regard.

In sum, aside from the absence of the pointing handshape and a small number of other infrequently used handshapes, blind children's gestures resembled those used by the sighted children in both form and in content. The fact that children who have never seen others gesture can nevertheless move their hands in ways that look just like a sighted person's gestures suggests that visual experience is not essential to the development of gesture.

The resilience of gesture. Our data suggest that gesture is resilient to wide variations in environmental input. In the extreme, we have found that gesture can even appear in the communicative repertoires of blind children whose lack of sight prevents them from using the gestures around them as a model. In this regard, it is worth noting that communication in the manual modality is, in general, quite resilient. For example, deaf children whose hearing losses prevent them from profiting from the spoken linguistic input that surrounds them and whose hearing parents have not yet exposed them to input from a conventional sign language have been found to use gesture to communicate (Feldman, Goldin-Meadow, & Gleitman, 1978; Gol-

din-Meadow & Feldman, 1977; Goldin-Meadow & Mylander, 1990). Thus, gesture appears to be a robust component of communication.

Interestingly, however, although robust in terms of its presence, gesture is chameleon-like with respect to both its form and function. When gesture is used along with a spoken system (as in the blind as well as the sighted child), it takes on the global and synthetic properties that have been shown to characterize gesture when it serves as part of an integrated gesture-speech system (McNeill, 1992). Moreover, an important finding of our study of blind children is that gesture takes on these properties even if they have not been explicitly modeled for the child. In contrast, when gesture is forced to assume the full burden of communication on its own (as in the deaf children of hearing parents described by Goldin-Meadow and Mylander, 1984), gesture takes on the linear and segmented properties that characterize all language systems, be they spoken or signed (Goldin-Meadow et al., 1996). Here again, gesture takes on these language-like properties even if they have not been explicitly modeled for the child (Goldin-Meadow, Butcher, Mylander, & Dodge, 1994; Goldin-Meadow & Mylander, 1983, 1984; Goldin-Meadow, Mylander, & Butcher, 1995).

In sum, not only is gesture integral to communication, but gesture can also adjust to the speaker's communicative situation. It assumes the global and synthetic properties of an integrated gesture-speech system when used along with speech, and it assumes the linear and segmented properties of a language system when speech is not available. Finally, and perhaps most strikingly, this adjustment appears to take place even when there is no explicit model to guide it.

Gesture Is Not Produced in All Contexts

We found that even within our sighted sample, gesture was not produced with the same frequency in all contexts. The sighted children, regardless of whether they were blindfolded, produced gestures on the conservation and directions tasks but not on the narrative task. It is important to note that the absence of gesturing on this narrative task does not mean that speakers do not gesture when they narrate. Indeed, McNeill's (1992) seminal work on gesture has focused almost exclusively on gestures produced in a narrative context, in particular, when participants are asked to retell a cartoon or film to a listener. It is not clear why the particular narrative task we used in our study failed to elicit gesture in any of the groups. Perhaps the fact that the children in our study heard the story rather than viewing a cartoon contributed to the absence of gesture. It is also possible that the story we used was too simple for our participants, requiring very little imagistic elaboration for self or for other. In any case, McNeill's work indicates clearly that the narrative genre itself is not to blame for the absence of gesture on this task in our study.

A potentially more interesting case of gesture absence was found on the directions task—the blind children rarely gestured on this task, while the sighted children gestured a great deal. We suggest that this difference in gesture production reflects the fact that the blind child's experience with routes is fundamentally different from the sighted child's. Whereas sighted children are able to construct path representations based on

visual input that is available at a single glance, blind children must instead rely on proprioception and audition to obtain information about a path (Cratty, 1971). The path, as perceived by the body and the ear, tends not to be apprehended all at once (as it would be if seen by the eye) but rather tends to be constructed serially out of segmented inputs from each location along the path as it is touched or reverberates sound.

Because gesture is particularly good at capturing global images (cf. McNeill, 1992), it may be easier to encode the holistic path (i.e., the continuous trajectory) that is given by the eye in gesture than the sequential path (i.e., the progression of locations) that is given by the body and the ear. On this view, the sighted children in our study, who were able to see the path as a single unit, would generate task representations that were easily captured both in speech (by a description containing few landmarks) and in gesture (by a movement portraying the path as a single whole). In contrast, the blind children, who tended to break up the path into a progression of locations, would generate task representations that were easily captured in speech (by a description containing a series of landmarks demarcating each location in the path) but not in gesture.

Thus, we are suggesting that it is speakers' mental representations—not their visual status—that dictate whether a path will be described in gesture as well as speech. In support of this hypothesis, we presented data indicating that the few gestures the blind child produced on the directions task were produced when the child verbally represented a path as a single move (i.e., when they described it in speech without dividing it into a series of locations). Conversely, sighted children who, at times, described paths as a progression of locations (i.e., used landmarks in some of their spoken descriptions of paths) never gestured on those paths and consequently gestured less than the sighted children who did not represent their paths in this way. These findings suggest that the blind and sighted children in our study did not differ in their ability to produce gesture *per se*. Rather, they differed in the predominant way that they represented a path when asked to describe it for another. It is this difference in representation, we would argue, that yields gesture on the directions task in sighted but not blind children.^{11,12}

In contrast, it is likely that representations underlying the blind children's descriptions in the conservation task, first, were no different from the sighted children's representations and, second, supported gesture in ways that task representations involved in navigating space did not. The conservation task involved objects that sighted children explored visually and blind children explored manually. As Kennedy (1993) has suggested, spatial properties of surfaces (e.g., the corners and edges of objects) may be as accessible to touch as they are to vision. Haptic and visual perceptual systems may both involve extraction of information over time and the information extracted may be cross-modally invariant. If so (and Kennedy's, 1993, own finding that individuals blind from birth are quite capable of recognizing objects and figures from raised line drawings is consistent with this view), then it may not matter whether object exploration takes place with the eyes or with the hands. In other words, object exploration, unlike spatial navigation, may involve cues that are equally accessible to blind and sighted children. The similarities in gesture production across the blind and sighted groups on the conservation task may thus reflect

commonalities in their underlying representations of the task, just as the differences in gesture production across these groups on the directions task may reflect differences in their underlying representations of the task.

We have found that under certain circumstances blind children can and do gesture. Moreover, despite their lack of visual experience with the gestures of others, blind children produce gestures that resemble the gestures used by sighted children in both form and content. Taken together, these findings suggest that visual experience is not essential to gesture development. Furthermore, the fact that, as listeners, blind children are unable to appreciate the communicative value of gesture, yet, as speakers, produce gestures suggests that gesture plays a role for the speaker that is independent of its role for the listener.

¹¹ We are not suggesting that the blind children differed from the sighted in their ability to conceptualize space (although this has been suggested in studies of spatial cognition in blind adults; cf. Hartlage, 1969; Rieser et al., 1980). It may be true that the blind children in our study conceptualized the layout of their schools differently from the sighted children; however, our data are relevant only to the task of giving directions.

¹² Our findings suggest that the presence of gesture on a task is determined, at least in part, by the speaker's representation of that task. However, it is possible that the listener also plays a role in contributing to the amount of gesture a speaker produces. Because the blind children in our study could not appreciate the communicative value of gesture, they were not likely to gesture for the benefit of the listener on any task. The fact that the blind children did not gesture on our directions task therefore leaves open the possibility that, on this task, gesture may be produced primarily for the listener rather than for the speaker.

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