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REPORT

The resilience of gesture in talk: gesture in blind speakers and listeners

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Abstract

Spontaneous gesture frequently accompanies speech. The question is why. In these studies, we tested two non-mutually exclusive possibilities. First, speakers may gesture simply because they see others gesture and learn from this model to move their hands as they talk. We tested this hypothesis by examining spontaneous communication in congenitally blind children and adolescents. Second, speakers may gesture because they recognize that gestures can be useful to the listener. We tested this hypothesis by examining whether speakers gesture even when communicating with a blind listener who is unable to profit from the information that the hands convey. We found that congenitally blind speakers, who had never seen gestures, nevertheless gestured as they spoke, conveying the same information and producing the same range of gesture forms as sighted speakers. Moreover, blind speakers gestured even when interacting with another blind individual who could not have benefited from the information contained in those gestures. These findings underscore the robustness of gesture in talk and suggest that the gestures that co-occur with speech may serve a function for the speaker as well as for the listener.

When people talk, they gesture. Gestures accompany talk in speakers from varied cultural and linguistic backgrounds (e.g. Feyereisen & de Lannoy, 1991); they complement and, at times, supplement the information conveyed in talk (McNeill, 1992; Alibali & Goldin-Meadow, 1993; Goldin-Meadow, Alibali & Church, 1993); and they influence the overall message that listeners apprehend (Goldin-Meadow, Wein & Chang, 1992; McNeill, Cassell & McCullough, 1994; Alibali, Flevares & Goldin-Meadow, 1997). These and other findings have led McNeill (1992) to argue that gesture and speech form a single, integrated system of communication in which production in the two modalities reflects a common underlying cognitive representation.

Why do speakers gesture? Two different, and not mutually exclusive, answers immediately come to mind, one focusing on the mechanisms underlying the acquisition of gesture, and the other focusing on its functions. First, speakers may gesture simply because they see others gesture and learn from this model to move their hands as they talk. We test this hypothesis in Study 1 by exploring whether individuals who have been blind from birth – and thus have not seen gesture – nevertheless gesture as they talk. Second, speakers may gesture because they recognize that the information conveyed in gesture may be useful to the listener. We test this hypothesis in Study 2 by exploring whether speakers gesture even when communicating with a listener known to be blind and thus unable to profit from information conveyed by the hands.

Study 1

Method

Participants

Participants were 12 congenitally blind children and adolescents (four males, eight females) ranging in age from 9;1 to 18;10 (M = 12;10 years;months) and 24 sighted children and adolescents ranging in age from 9;1 to 17;3. Blind participants were recruited for the study on the basis of the following criteria: (a) an ophthalmologic

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diagnosis of total congenital blindness or blindness with at best minimal light perception; (b) no other documented physical, neurological, cognitive or emotional deficits; and (c) age-appropriate performance in educational programs. Blind participants came from lower-middle-class to middle-class families residing in the midwestern and eastern USA. Half of the participants attended state residential schools for the blind; the remaining half were enrolled in educational programs that combined mainstreaming with additional work designed for visually impaired students (two in private and four in public schools).

Sighted participants (eight males, 16 females) were recruited from public and private schools in the western, midwestern and eastern USA serving populations roughly similar to those from which blind participants were drawn. Sighted individuals were matched to blind participants on the basis of age, gender and ethnicity and were randomly assigned to one of two conditions within matching constraints: the 12 participants in the blindfolded group (M = 12;8) wore a blindfold throughout the session; the 12 participants in the sighted condition (M = 11;11) were permitted to use normal vision.

Materials and procedure

Four Piagetian conservation tasks (continuous quantity, length, number and mass) were presented in a fixed order. These tasks were selected because they have been found to elicit gesture routinely in sighted individuals (Church & Goldin-Meadow, 1986). Stimulus materials were adapted for use with visually impaired participants. Each task consisted of three phases: initial equality, transformation, and final equality. For example, in the initial equality phase of a continuous quantity task, two identical tall containers filled with water were placed in front of the child, and the child was asked to verify that the two containers held the same amounts of water. In the transformation phase, water was poured from one of the tall containers to a short container. Blind and blindfolded participants were asked to keep their hands over the experimenter's hands during the transformation phase of each task. Sighted children followed the transformation visually. The child was then asked the judgment question ('Do the two containers have the same or different amounts of water in them?') and the explanation question ('How can you tell?'). In the final equality phase, water 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 water. A similar procedure was followed for the remaining tasks (sticks, checkers, clay), each involving a different transformation (e.g. forming the two sticks into a 'T'; spreading out one of the rows of checkers; flattening one ball of clay). The session was videotaped, and informed consent was obtained from parents and children prior to the start of the session.

Coding

All spoken and gestured responses were transcribed from the videotapes. Hand movements were classified as gestures only when they had an identifiable beginning, a clear end *and* co-occurred with speech. Instances of object manipulation and manual exploration were not coded as gestures. These criteria were employed to avoid the possibility of classifying instances of manual exploration in blind and blindfolded participants as gestures and to make a distinction between continuous hand movements versus gestures in blind participants.

We described the *form* of each gesture in terms of the shape of the moving hand and the trajectory of the 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. We also coded the *content* of each gestured response to the explanation question using a system developed by Church and Goldin-Meadow (1986). For example, a C-shaped hand swept horizontally from the tall container toward the short container portrayed the action that the experimenter used to transfer the water from the original container, and was classified as a 'transform' gesture; the same movement reversing the action (i.e. moving from the short to the tall container) portrayed how the experimenter could return the water to its original state, and was classified as a 'reversibility' gesture (see Table 1 for additional examples). Agreement between two independent coders was 90% for handshape form, 87% for motion form and 79% for gesture content.

All statistical analyses were nonparametric, two-tailed comparisons using the Mann–Whitney U Test. To maximize statistical power and employ orthogonal comparisons, we first contrasted sighted and blindfolded participants' performance on the task. If no significant difference existed, the two groups were collapsed and blind participants were compared with this combined group.

Results and discussion

Despite their lack of visual–gestural input, all of the blind speakers gestured. Blind and sighted participants did not differ significantly in the number of gestures

Table 1 *Examples of explanations in speech and gesture*

Types of explanations	Speech	Gesture
Noncomparative		
Indication	'That's a stick.'	Point to the unchanged stick
Description	'This one's tall.'	Flat palm held at height of water on unchanged container
Nonequivalence		
Comparison	'This one's tall and that one's short.'	Flat palm held at height of water on unchanged container, and then at height of water on changed container
Transform	'You flattened it.'	Up and down movement with flat palm over the changed Playdoh (i.e. over the sausage-shaped clay)
Equivalence		
Identity	'These two are the same length.'	Two flat palm hands held at the endpoints of the changed stick and then at the endpoints of the unchanged stick to indicate the identical lengths of the two sticks
Reversibility	'If you squished them together, they would still be the same.'	Two C-hands sweep horizontally as though pushing checkers back together into a compressed line

produced per task (Figure 1, top left panel; $U = 136.0$, ns; comparing blind participants to the combined sighted groups, which did not differ from one another, $U = 50.0$, ns). Moreover, when the blind participants gestured, they produced as many gestures as their sighted peers. With respect to number of words produced per task, sighted, blindfolded and blind participants also did not differ significantly (Figure 1, bottom left panel; $U = 139.0$, ns; comparing blind to the combined sighted groups, which did not differ from one another, $U = 49.5$, ns).

We next asked whether blind participants' conservation explanations resembled those of their sighted peers in content. Table 2 presents mean proportions for the three major classifications of conservation rationales (noncomparative, nonequivalence, equivalence) produced in speech and gesture by the sighted, blindfolded and blind participants. The participants produced primarily equivalence explanations, some nonequivalence explanations, and almost no noncomparative explanations in speech. The pattern was different in gesture, but was the same across the three groups: the participants produced primarily noncomparative explanations, and many fewer nonequivalence and equivalence explanations. Note that the sighted participants produced no equivalence explanations in gesture. Interestingly, the temporary loss of sight seemed to encourage the blindfolded participants to produce advanced explanations in gesture (they produced more equivalence explanations in gesture, and fewer in speech, than the sighted participants). The blind participants' patterns fit somewhere between the distributions for the two sighted groups. To determine how fine-grained the gestural similarities between the groups were, we examined the particular dimensions of the task objects that participants displayed in gesture. Blind participants conveyed precisely the same spatial dimensions in their gestures as did both groups of sighted children – height, length, placement, shape and orientation. Thus, gestures of blind and sighted

Table 2 *Types of spoken and gestured explanations produced by sighted, blindfolded and blind participants*[a]

	Sighted ($N = 12$)	Blindfolded ($N = 12$)	Blind ($N = 12$)	Blind with blind ($N = 4$)	Blind with sighted ($N = 3$)
Spoken explanations					
Noncomparative	0.03 (0.08)	0.05 (0.08)	0.04 (0.07)	—	0.10 (0.10)
Nonequivalent	0.12 (0.14)	0.29 (0.22)	0.23 (0.31)	0.78 (0.20)	0.72 (0.10)
Equivalent	0.85 (0.15)	0.66 (0.27)	0.73 (0.34)	0.22 (0.20)	0.18 (0.08)
Gestured explanations					
Noncomparative	0.89 (0.30)	0.58 (0.26)	0.75 (0.27)	0.54 (0.19)	0.50 (0.22)
Nonequivalent	0.11 (0.30)	0.19 (0.18)	0.15 (0.23)	0.42 (0.24)	0.46 (0.26)
Equivalent	—	0.23 (0.30)	0.10 (0.21)	0.04 (0.08)	0.05 (0.08)

[a] The table displays the mean proportion (and standard deviation) of spoken and gestured explanations produced by participants in each group.

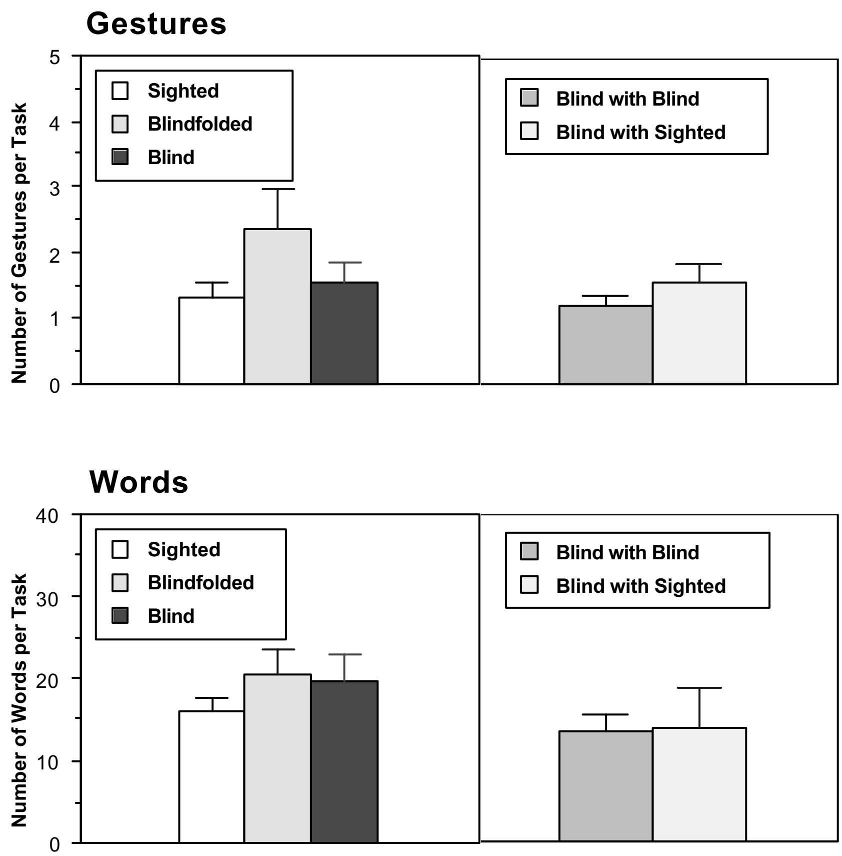

Figure 1 *The mean number of gestures and words produced per task by sighted, blindfolded and blind participants interacting with a sighted experimenter (N = 12 per group) and by a group of blind children interacting with a blind experimenter (N = 4). The blind with blind group is compared with a subset of the blind participants who interacted with a sighted experimenter (blind with sighted, N = 3), matched for level of performance on the conservation tasks. There were no significant differences in either gesture or speech production comparing blind participants with the combined group of sighted and blindfolded participants (left panels), or comparing blind participants interacting with blind versus sighted experimenters (right panels). The error bars reflect standard errors.*

speakers conveyed the same types of task-related information.

Table 3 presents the mean proportion of each motion and handshape form produced by sighted, blindfolded and blind participants. With respect to types of *motions*, the distribution of forms that the blind participants used again fell somewhere between the two sighted groups – the blindfolded participants used all six forms, the sighted used only three and the blind used five. Moreover, there were differences in the frequency with which specific forms were used. Sighted participants tended to hold their gestures in place over the task objects, while blind and blindfolded participants often added some form of motion (a pat for the blind, a horizontal sweep for the blindfolded).

With respect to types of *handshapes*, all three groups made use of all four forms. Again, there were differences in distribution. Sighted speakers frequently used the pointing handshape (with the index finger extended), while blind and blindfolded participants rarely did so (preferring instead to use the entire palm with either four or five fingers extended). The pointing gesture has two functions: to indicate an object, and to establish a visual 'line of regard'. Even though blind participants rarely used the pointing handshape, many of their gestures *did* serve an indication function; in fact, 50% of their gestured explanations were classified as Indications (cf. Table 1; these gestures are included in the noncomparative category in Table 2; the blind participants typically conveyed Indications by singling out a part of the display with a palm rather than a pointing hand). Thus, blind speakers' failure to point was not a failure to indicate.

We suggest that the absence of the pointing handshape in the blind group was caused by difficulty in establishing a visual line of regard. Visual line of regard

Table 3 *Form of gestures produced by sighted, blindfolded and blind participants*[a]

	Sighted (N = 12)	Blindfolded (N = 12)	Blind (N = 12)	Blind with blind (N = 4)	Blind with sighted (N = 3)
Type of motion					
No motion	0.84 (0.20)	0.51 (0.24)	0.41 (0.38)	0.43 (0.07)	0.36 (0.39)
Pat in place	—	0.13 (0.21)	0.47 (0.43)	0.24 (0.20)	0.43 (0.51)
Vertical sweep	—	0.04 (0.09)	—	0.08 (0.10)	—
Horizontal sweep	0.14 (0.18)	0.22 (0.21)	0.06 (0.12)	0.23 (0.14)	0.03 (0.06)
Up/down motion	0.02 (0.05)	0.06 (0.07)	0.05 (0.09)	—	0.14 (0.12)
Trace shape of object	—	0.02 (0.06)	0.01 (0.03)	0.03 (0.06)	0.03 (0.06)
Type of handshape					
Pointing, finger extended	0.72 (0.29)	0.18 (0.29)	0.03 (0.07)	—	0.07 (0.12)
Palm, 5 fingers spread	0.10 (0.21)	0.50 (0.40)	0.66 (0.29)	0.53 (0.25)	0.38 (0.07)
Palm, 4 fingers spread	0.06 (0.14)	0.18 (0.25)	0.14 (0.25)	0.39 (0.24)	0.30 (0.30)
C-shaped hand	0.08 (0.14)	0.13 (0.14)	0.16 (0.18)	0.08 (0.06)	0.25 (0.28)

[a] The table displays the mean proportion (and standard deviation) of gestural motions and gestural handshapes of each type produced by participants in each group. Types of motion forms and handshape forms are included in the table only if at least one of the groups produced a minimum of 0.03 instances of that type.

is a line of reference that extends down the length of the arm in the direction of the extended index finger and has two endpoints: the pointer's eyes and the referent of the gesture (Butterworth & Grover, 1990). Without vision, it is difficult to establish a line between the pointer's eyes, the index finger and the gestural referent. The low rate of pointing in these school-aged and adolescent blind children is consistent with reports that, when very young blind children in the initial stages of language development indicate objects with their hands, they tend to do so using a palm handshape rather than a pointing handshape (e.g. Urwin, 1979; Iverson, Tencer, Lany & Goldin-Meadow, 2000). The fact that the blindfolded children also use pointing gestures infrequently suggests that even temporary loss of vision affects the ability to establish line of regard.

An additional similarity between the blind and blindfolded groups was also apparent when patterns of hand preference in gesture production were analyzed. Each gesture was categorized according to whether it was executed by the right hand, the left hand or both hands. Consistent with findings reported by Kimura (Lavergne & Kimura, 1987; see also Kimura, 1993), the vast majority of gestures produced by sighted participants were performed with the right hand ($M = 0.87$, SD = 0.31). Interestingly, however, the right hand preference was much less pronounced among blindfolded ($M = 0.47$, SD = 0.16) and blind ($M = 0.35$, SD = 0.29) participants. This is an intriguing finding, one which suggests that hand preference for gesturing can be influenced by an absence of vision, be it temporary or permanent.

In sum, congenitally blind children and adolescents gesture spontaneously when they talk even though they have had no visual model for their gestures; and they do so with a frequency and in a manner resembling that of their sighted peers. The emergence of gesture in the speaking process apparently does not require the opportunity to watch others gesture.

Study 2

Does the production of gesture depend on the speaker's general recognition that gesture serves a communicative function? Or is gesture such a central part of the speaking process that it will even appear under conditions in which speakers are quite aware that the listener cannot apprehend their gestures? Study 2 addressed these questions by assessing whether blind speakers continue to produce spontaneous gestures along with their speech even when they know that their listener is blind and cannot conceivably see those gestures.

Method

Participants

Four additional children blind from birth (three females, one male; ages 5;0 to 8;6, M = 7;6) participated in Study 2. Children were selected for participation based on the criteria described above. All attended a residential state school for the blind and came from middle-class families. The four blind children were younger than our original group of blind children interacting with a sighted experimenter, and were less advanced in their understanding of conservation. We therefore compared the production of these four children with that of a subset of the original group who produced incorrect (i.e. 'different') judgments in speech on the conservation task

($N = 3$, ages 9;1 to 12;11, $M = 12;8$). On average, the four blind children interacting with a blind experimenter produced 2.0 (SD = 1.8) incorrect judgments (out of 8); the three blind children interacting with a sighted experimenter also produced 2.0 (SD = 1.0).

Procedure

The procedure was identical to that employed in Study 1, but this time the experimenter was blind. To ensure that children were aware of this fact, they were escorted from their classroom by the blind experimenter (walking with a cane). The experimenter discussed the fact that she was blind, and showed participants the Braille script that she was to use during the session.

Results and discussion

All four of the blind children were found to gesture even though they were interacting with an experimenter known to be blind. Moreover, they gestured at a rate not reliably different from that of the matched blind children interacting with a sighted experimenter (Figure 1, top right panel; $U = 2.0$, ns).

The content of the children's spoken and gestured explanations was identical to that of blind speakers interacting with a sighted experimenter (cf. Table 2). Note that the participants described in the two right-hand columns produced more nonequivalence explanations than the other participants. These children did not have a firm grasp of conservation, a fact that was apparent not only in their speech but also in their gesture.

The children used essentially the same motion and handshape forms as participants interacting with sighted individuals. Their distribution of forms resembled the distribution for blindfolded speakers, as was the case for blind speakers interacting with sighted listeners.

In sum, gesture production does not appear to depend on speakers' recognition that their gestures enhance communication to the listener. This finding is consistent with data indicating that sighted speakers continue to gesture even under conditions in which the listener cannot see their gestures (e.g. Cohen & Harrison, 1973; Cohen, 1977; Rimé, 1982).

Conclusion

Our findings suggest that gesturing is an intrinsic part of the speaking process. Gestures are produced by congenitally blind speakers who have never seen a speaker gesture. They are even produced when blind speakers knowingly interact with a blind listener who cannot see their gestures and cannot therefore appreciate the information they convey. The tasks our participants were asked to perform involved objects, and indeed all of the participants produced their gestures in relation to those objects. It is therefore possible that these types of tasks are particularly good at eliciting gesture in congenitally blind individuals, and that blind individuals produce only these types of gestures (they may, for example, be unable to produce metaphoric gestures). In this regard, it is important to note that congenitally blind children have been found to gesture when performing other types of tasks, e.g. giving route directions or describing small-scale spatial layouts (Iverson, 1999). Although future work is needed to determine the breadth of the blind individual's gestural repertoire, our findings make it clear that when congenitally blind individuals *do* produce gestures they do so at the same rate, and in the same manner, as sighted individuals. This phenomenon underscores the robustness of speech-accompanying gesture.

Our findings also suggest that gesture's function may not be restricted to communicating to listeners. Gesture may also play a role for the speaker (cf. Goldin-Meadow, 1999, 2000). Gesture frequently accompanies speech in reasoning tasks, such as conservation, in which the speaker must think through a problem (Goldin-Meadow *et al.*, 1993). In conservation tasks, participants are required to consider and manipulate relationships between several different spatial dimensions of the task objects simultaneously (e.g. in the liquid quantity task, the relationship between height, width and water level). Characteristics of these dimensions and their relationships may be more easily expressed in the imagistic medium offered by gesture than in the linear, segmented medium provided by speech (cf. McNeill, 1992). Gesture may thus provide speakers with an additional channel for expressing thoughts that are difficult to articulate in speech. As a result, speakers – even blind speakers – may produce gestures when explaining their reasoning in conservation tasks because some of their thoughts about the task lend themselves more readily to gesture than to speech. Gesture, in other words, might simply reflect a speaker's thoughts in a medium that happens to be relatively transparent to most listeners. The point we stress here is that this medium is such a natural accompaniment to speech that it is exploited by speakers even when its use has not been explicitly modeled for them, and when its communicative function is not immediately apparent.

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