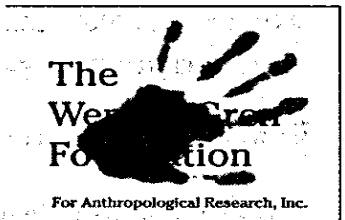

Roots of Human Sociality

Culture, Cognition and Interaction

Edited by

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BERG
Oxford • New York

English edition
First published in 2006 by
Berg
Editorial offices:
First Floor, Angel Court, 81 St Clements Street, Oxford OX4 1AW, UK
175 Fifth Avenue, New York, NY 10010, USA

Berg is the imprint of Oxford International Publishers Ltd.

Library of Congress Cataloging-in-Publication Data

Roots of human sociality : culture, cognition and interaction / edited by N.J. Enfield and Stephen C. Levinson. – English ed.
p. cm. – (Wenner-gren international symposium series)
Includes bibliographical references and index.
ISBN-13: 978-1-84520-394-8 (pbk.)
ISBN-10: 1-84520-394-1 (pbk.)
ISBN-13: 978-1-84520-393-1 (cloth)
ISBN-10: 1084520-393-3 (cloth)
1. Social interaction. 2. Human evolution. 3. Social evolution. I. Enfield, N. J., 1966- II. Levinson, Stephen C.
HM1111.E64 2006
306.01–dc22

2006021669

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

ISBN-13 978 1 84520 393 1 (Cloth)
978 1 84520 394 8 (Paper)

ISBN-10 1 84520 393 3 (Cloth)
1 84520 394 1 (Paper)

Typeset by JS Typesetting Ltd, Porthcawl, Mid Glamorgan
Printed in the United Kingdom by Biddles Ltd, King's Lynn

www.bergpublishers.com

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Meeting Other Minds through Gesture: How Children Use their Hands to Reinvent Language and Distribute Cognition

Susan Goldin-Meadow

The premise of this book and the conference that led to it is that our mentally mediated and highly structured way of interacting with one another is what makes us uniquely human (Enfield and Levinson this volume). Over the course of generations, we have developed patterns of social organization and values that set the stage for each new generation of children to interact in human ways. Indeed, children inherit a world of social organization that scaffolds their development and releases them from reinventing with each new generation the patterns that make us uniquely human—they can borrow the wheel from their elders.

One of the most pervasive aspects of social organization is human language. Every human culture discovered thus far has developed a linguistic system that is shared by all of its members and pervades the way those members interact with one another. Even deaf cultures that do not have access to the aural modality develop linguistic systems, albeit in the manual modality. These signed languages provide the medium of interaction for deaf individuals within a community and define Deaf culture (Padden and Humphries 1988). When children, be they deaf or hearing, acquire the language of their parents, they do more than learn a conventional code—they take important steps toward becoming functioning members of their society.

The question I address in this chapter is what happens when a child does not have access to the shared conventional language of his or her

community? Would such a child be able to interact with members of the community? And if so, would these interactions with other humans serve as a scaffold, allowing the child to reinvent the linguistic structure that has come to epitomize what is unique about humans?

We know that children do not invent a linguistic system to communicate if they have been raised by animals (Skuse 1988) or by humans who treat them inhumanely (Curtiss 1977). This is the first hint that human interaction may be essential to language and not the other way around. But children raised by animals not only lack human interaction, they also lack access to conventional language. Would children who do not have access to conventional language but *do* have access to humans willing to interact with them be able to invent a linguistic system?

I begin this chapter by describing children in just such a situation—children who have not been exposed to a conventional language model but in all other respects are raised in a typically human environment. The children are deaf with hearing losses so severe that they cannot learn the spoken language that surrounds them. Moreover, they are born to hearing parents who have not exposed them to a sign language. Despite the lack of a usable model for conventional human language, these children interact and communicate with other humans and use gesture to do so. Even more striking, the children's gestures exhibit many of the structural and functional properties found in human language. This phenomenon of language creation in deaf children tells us that an individual child can reinvent the linguistic wheel, or at least its rudimentary aspects—as long as the child can interact with humans who behave humanely.

The Gestures Children Produce when they have no Language: Using Gesture to Reinvent Language

The Deaf Children's Gestures Exhibit Linguistic Structure

Deaf children born to deaf parents and exposed from birth to a conventional sign language such as American Sign Language (ASL) progress through stages in acquiring sign language as naturally as hearing children acquiring a spoken language (Newport and Meier 1985). However, 90 percent of deaf children are not born to deaf parents who could provide early exposure to a conventional sign language. Rather, these deaf children are born to hearing parents who, quite naturally, expose their children to speech (Hoffmeister and Wilbur 1980). Unfortunately, it is extremely uncommon for deaf children with severe to profound

hearing losses to acquire the spoken language of their hearing parents naturally, that is, without intensive and specialized instruction. Even with instruction, deaf children's acquisition of speech is markedly delayed when compared either to the acquisition of speech by hearing children of hearing parents, or to the acquisition of sign by deaf children of deaf parents. By age five or six, and despite intensive early training programs, the average profoundly deaf child has limited linguistic skills in speech (Mayberry 1992). Moreover, although many hearing parents of deaf children send their children to schools in which one of the manually coded systems of English is taught, some hearing parents send their deaf children to "oral" schools in which sign systems are neither taught nor encouraged; thus, these deaf children are not likely to receive input in a conventional sign system. Under such inopportune circumstances, a child might be expected to fail to communicate, or perhaps to communicate only in nonsymbolic ways. However, this turns out not to be the case.

I, along with my colleagues, have studied ten American and four Chinese deaf children who were unable to acquire spoken language and were not exposed to sign language. All of the children used gesture, called "home signs," to communicate and those gestures exhibited properties that are fundamental to natural languages. The linguistic properties that appear in the deaf children's gesture systems can be considered "resilient"—likely to crop up in a child's communications whether or not that child is exposed to a conventional language model. Table 13.1 lists the resilient properties we have identified thus far (Goldin-Meadow 2003b). There may be many others—just because we have not found a particular property in a deaf child's home-sign gesture system does not mean it is not there. And there are likely to be linguistic properties that the deaf children cannot invent, properties that can only be invented by a community of gesture users (Goldin-Meadow 2005; see Pyers this volume, for a description of what can happen when a group of home signers come together and develop a shared sign system that is then passed onto a new generation of signers). I begin by describing the word- and sentence-level properties that the deaf children developed in their gesture systems.

Words

The deaf children's gesture words have five properties that are found in all natural languages. The gestures are *stable* in form, although they need not be. It would be easy for the children to make up a new gesture to fit

Table 13.1. The resilient properties of language

The resilient property	*As instantiated in the deaf children's gesture systems*
Words	
Stability	Gesture forms are stable and do not change capriciously with changing situations
Paradigms	Gestures consist of smaller parts that can be recombined to produce new gestures with different meanings
Categories	The parts of gestures are composed of a limited set of forms, each associated with a particular meaning
Arbitrariness	Pairings between gesture forms and meanings can have arbitrary aspects, albeit within an iconic framework
Grammatical Functions	Gestures are differentiated by the noun, verb, and adjective grammatical functions they serve
Sentences	
Underlying Frames	Predicate frames underlie gesture sentences
Deletion	Consistent production and deletion of gestures within a sentence mark particular thematic roles
Word Order	Consistent orderings of gestures within a sentence mark particular thematic roles
Inflections	Consistent inflections on gestures mark particular thematic roles
Recursion	Complex gesture sentences are created by recursion
Redundancy Reduction	Redundancy is systematically reduced in the surface of complex gesture sentences
Language Use	
Here-and-Now Talk	Gesturing is used to make requests, comments, and queries about the present
Displaced Talk	Gesturing is used to communicate about the past, future, and hypothetical
Narrative	Gesturing is used to tell stories about self and others
Self-Talk	Gesturing is used to communicate with oneself
Meta-Language	Gesturing is used to refer to one's own and others' gestures

every new situation (and that appears to be what hearing speakers do when they gesture along with their speech; cf. McNeill 1992). But that is not what the deaf children do. They develop a stable store of forms that they use in a range of situations—they develop a lexicon that is an essential component of all languages (Goldin-Meadow et al. 1994).

Moreover, the gestures the children develop are composed of parts that form *paradigms*, or systems of contrasts. When the children invent a gesture form, they do so with two goals in mind—the form must not only capture the meaning they intend (a gesture–world relation), but it must also contrast in a systematic way with other forms in their repertoire (a gesture–gesture relation). In addition, the parts that form these paradigms are *categorical*. For example, one child, David, used a *fist* hand shape to represent grasping a balloon string, a drumstick, and handlebars—grasping actions requiring considerable variety in diameter in the real world. The child did not distinguish objects of varying diameters within the *fist* category, but did use his hand shapes to distinguish objects with small diameters as a set from objects with large diameters (e.g., a cup, a guitar neck, or the length of a straw) that were represented by a *C*-shaped hand. The manual modality can easily support a system of analog representation, with hands and motions reflecting precisely the positions and trajectories used to act on objects in the real world. But the children do not choose this route. They develop categories of meanings that, although essentially iconic, have hints of *arbitrariness* about them—that is, the boundaries between categories are not drawn in the same places in the children's gesture systems (Goldin-Meadow et al. 1995).

Finally, the gestures the children develop are differentiated by *grammatical function*. Some serve as nouns, some as verbs, some as adjectives. As in natural languages, when the same gesture is used for more than one grammatical function, that gesture is marked (morphologically and syntactically) according to the function it plays in the particular sentence (Goldin-Meadow et al. 1994). For example, if a child were to use a twisting gesture in a verb role, that gesture would likely be produced near the jar to be twisted open (i.e., it would be inflected), it would not be abbreviated, and it would be produced *after* a pointing gesture at the jar. In contrast, if the child were to use the twisting gesture in a noun role, the gesture would likely be produced in neutral position near the chest (i.e., it would not be inflected), it would be abbreviated (produced with one twist rather than several), and it would occur *before* the pointing gesture at the jar.

Sentences

The deaf children's gesture sentences have six properties found in all natural languages. Underlying each sentence is a *predicate frame* that determines how many arguments can appear along with the verb in the surface structure of that sentence (Goldin-Meadow 1985). For example, four slots underlie a gesture sentence about transferring an object, one for the verb and three for the arguments (actor, patient, and recipient). In contrast, three slots underlie a gesture sentence about eating an object, one for the verb and two for the arguments (actor and patient).

Moreover, the arguments of each sentence are marked according to the thematic role they play. There are three types of markings that are resilient (Goldin-Meadow and Mylander 1984; Goldin-Meadow et al. 1994):

(1) *Deletion*—The children consistently produce and delete gestures for arguments as a function of thematic role; for example, they are more likely to delete a gesture for the object or person playing the role of transitive actor (soldier in "soldier beats drum") than they are to delete a gesture for an object or person playing the role of intransitive actor (soldier in "soldier marches to wall") or patient (drum in "soldier beats drum").

(2) *Word order*—The children consistently order gestures for arguments as a function of thematic role; for example, they place gestures for intransitive actors and patients in the first position of their two-gesture sentences (soldier–march; drum–beat).

(3) *Inflection*—The children mark with inflections gestures for arguments as a function of thematic role; for example, they displace a verb gesture in a sentence toward the object that is playing the patient role in that sentence (the "beat" gesture would be articulated near, but not on, a drum).

In addition, *recursion*, which gives natural languages their generative capacity, is a resilient property of language. The children form complex gesture sentences out of simple ones (Goldin-Meadow 1982). For example, one child pointed at me, produced a "wave" gesture, pointed again at me, and then produced a "close" gesture to comment on the fact that I had waved before closing the door—a complex sentence containing two propositions: "Susan waves" (proposition 1) and "Susan closes door" (proposition 2). The children systematically combine the predicate frames underlying each simple sentence, following principles of sentential and phrasal conjunction. When there are semantic elements that appear in both propositions of a complex sentence, the children

have a systematic way of *reducing redundancy*, as do all natural languages (Goldin-Meadow 1982, 1987).

The Hearing Parents' Gestures do not Exhibit Linguistic Structure

Hearing parents gesture when they talk to young children (Bekken 1989; Iverson et al. 1999; Ozcaliskan and Goldin-Meadow 2005; Shatz 1982) and the hearing parents of our deaf children were no exception. The deaf children's parents were committed to teaching them to talk and therefore talked to their children as often as they could. And when these parents talked, they gestured. Perhaps parents' gestures served as a model for their children's gestures.

To find out, my colleagues and I looked at the gestures that the hearing mothers produced when talking to their deaf children. We looked at them not like they were meant to be looked at (i.e., integrated with the speech they accompanied), but as a deaf child might look at them. We turned off the sound and analyzed the gestures using the same analytic tools that we used to describe the deaf children's gestures. We found that the hearing mothers' gestures do not resemble their children's and indeed do not have structure at all when looked at from a deaf child's point of view (Goldin-Meadow and Mylander 1983, 1984, 1998; Goldin-Meadow et al. 1994, 1995).

The fact that the hearing parents' gestures look so different from their deaf children's underscores two points. First, the languagelike structure we see in the children's gestures cannot be traced back to the parents' gestures. Even if the deaf children are using their parents' gestures as a starting point for their gesture systems, they are clearly going well beyond that starting point, transforming the gestures they see into a system that looks very much like language. Second, the deaf children are producers of a linguistic system that they never receive. They see the cospeech gestures that their hearing parents produce, but they produce their own languagelike gestures. This is a very odd communicative situation, one in which parent and child do not share a common language and do not have an obvious mechanism for establishing common ground (Enfield this volume)—yet parent and child do manage to communicate, perhaps because they can call on the conversational mechanisms that Schegloff (this volume) considers to be universal to all human interaction.

Parent and Child Communicate Nonetheless

Talk about the Present and Nonpresent

Like children learning conventional languages, the deaf children make requests, but they do so using gesture, and their parents comply (or at least they comply no less than parents of any young child). The parents comply because the children's gestures are relatively transparent when interpreted in context. As an example of a request, one child pointed at a nail and then produced a "hammer" gesture to ask his mother to bang on a nail. In addition, the children make comments on the here and now that are also relatively easy for the hearing parents to interpret. For example, a child produced a "march" gesture and then pointed at a mechanical toy soldier to comment on the fact that the soldier was, at that very moment, marching.

Talking about the here and now is important, but what language does particularly well is allow speakers to make reference to objects and events that are *not* perceptible to either the speaker or the listener—displaced reference (cf. Hockett 1960). Displacement allows us to describe a lost hat, to complain about a friend's slight, and to ask advice on college applications. If we were to communicate only about what is immediately in front of us, it is not at all clear that we would need as complex and productive a system as language is.

The deaf children are able to use their gestures to talk about the nonpresent, but these communications require a bit more interpretive work on the part of the children's hearing parents. In their earliest references to the nonpresent, the children describe what they know about an object or action and go beyond what is visible in doing so. One child pointed at a football, pointed at a rubber ball, and then produced a "kick" gesture to comment on the action that is characteristically done on footballs and rubber balls but that was not taking place at the time. Next, the children refer to events that take place prior to or after the communicative act but still during the observation session, that is, they refer to proximal events. After blowing a large bubble, one child pointed at the bubble and produced an "expand" gesture. Finally, the children refer to events in the past, events in the future, potential events, and even fantasy events. As an example, one child produced the following string of gesture sentences to indicate that, in preparation for setting up the cardboard chimney for Christmas, the family was going to move a chair downstairs.

1. Point at chair—"move away" gesture.
2. Point at chair—point downstairs.
3. "Chimney" gesture—"move away" gesture—"move here" gesture. Gloss: *We're going to move the chair away. We'll move it downstairs. We'll move the chair away and move the chimney here.*

Despite the absence of a shared linguistic code, the deaf children succeed in evoking nonpresent objects and events. They are able to do so primarily because their hearing parents know a great deal about their worlds and use that knowledge to interpret their gestures—the mother knew the Christmas ritual and was able to provide the context within which her child's gestures made sense. This process is reminiscent of interactions described by Goodwin (this volume) between a severely aphasic man and his family members. The difference is that the man with aphasia was at one time a fluent language user and, indeed, still understands everything that is said to him. He and his communication partners can draw on their shared linguistic knowledge to negotiate meaning. In contrast, the deaf children do not know their parents' spoken language or, for that matter, any conventional language at all. The fact that they manage to communicate with one another is that much more striking.

Telling Stories

Narrative is one of the most powerful tools that human beings possess for organizing and interpreting experience. Not only is narrative found universally across cultures (Miller and Moore 1989), but no other species is endowed with this capacity. Moreover, narrative emerges remarkably early in human development. Children from many sociocultural backgrounds, both within and beyond the United States, begin to recount their past experiences during the second and third years of life.

The deaf children told stories but used gesture to do so. They told stories about events they or others experienced in the past, events they hoped would occur in the future, and events that were flights of imagination (Phillips et al. 2001). For example, one child produced the following simple narrative in response to a picture of a car. His mother confirmed the tale by telling it later in her own words.

1. "Break" gesture—"away" gesture [= narrative marker]—point at dad—"car-goes-onto-truck" gesture (flat right hand glides onto back of flat left hand)

2. "Crash" gesture—"away" gesture [= narrative marker]
Gloss: *Dad's car broke and went onto a tow truck. It crashed.*

Note that, in addition to producing gestures to describe the event itself, the child produced what we have called a narrative marker. The child recognized that he was not describing an event that was taking place in the here and now. Rather, he was describing a real event that happened in another time and place. The child indicated this stance with an "away" gesture—a palm or point hand extended or arced away from the body (see Morford and Goldin-Meadow 1997). This gesture was used exclusively in narratives and served to mark a piece of gestural discourse as a narrative in the same way that "once upon a time" is often used to signal a story in spoken discourse.

Talking to Oneself and Talking about Talk

In addition to using their gestures to communicate with others, the deaf children used their gestures for a number of the other functions that language serves. These functions are not particularly frequent even in the communications of young children learning conventional languages. Indeed, all of our examples of these functions come from David, the child on whom we had the most observations. Although found in only one child, it is impressive that a child could extend his homemade gesture system to cover these rather sophisticated linguistic functions.

We occasionally saw David using his gestures when he thought no one was paying attention, as though "talking" to himself. Once when David was trying to copy a configuration of blocks off of a model, he made an "arced" gesture in the air to indicate the block that he needed next to complete the design. When offered a block that fit this description, David ignored the offer, making it clear that his gesture was not intended for anyone else but him. It seems extremely unlikely that a child would invent a language to talk to him- or herself. Genie who was left alone with no one to talk to for the first 13 years of her life did not, for example, invent a language to share thoughts with herself (Curtiss 1977). However, it is striking that, once having invented a language to communicate with others, children are able to use that system to communicate with themselves.

Another important use of language is its metalinguistic function—using language to talk about language. Language is unique in providing a system that can be used to refer to itself. It requires a certain level of

competence for a child to say, "the dog smells." It requires an entirely different and more sophisticated level for that child to say, "I said 'the dog smells.' " The child must be aware of his or her own talk and be able to report on that talk. David did, on occasion, use gesture to refer to his own gestures. For example, to request a Donald Duck toy that the experimenter held behind her back, David pursed his lips, referring to the Donald Duck toy. He then pointed at his own pursed lips and pointed toward the Donald Duck toy. When the experimenter offered him a Mickey Mouse toy instead, David shook his head, pursed his lips and pointed at his own pursed lips once again. The point at his own lips is roughly comparable to the words "I said," as in "I said 'Donald Duck.' " It therefore represents a communicative act in which gesture is used to refer to a particular act of gesturing and, in this sense, is reminiscent of young hearing children's quoted speech.

David also used gesture to comment on the gestures of others. For example, at one point we asked David and his hearing sister to respond, in turn, to videotaped scenes of objects moving in space. David was using his gesture system to describe the scenes, and his sister was inventing gestures on the spot (see Singleton et al. 1993). David considered his sister's response to be inappropriate on a number of the items, and he used his own gestures to correct her gestures. The sister extended her index finger and thumb as though holding a small object to describe a tree in a particular segment. Reacting to his sister's choice of hand shape, David teased her by reproducing the hand shape, pretending to gesture with it, and finally ridiculing the hand shape by using it to poke himself in the eyes. His sister then shrugged and said, "okay, so what should I do?"—a reaction that both acknowledged the fact that there was a system of which David was the keeper, and admitted her ignorance of this system. David then indicated that a point hand shape (which is an appropriate hand shape for straight thin objects in his system, and therefore an appropriate hand shape for a tree) would be a correct way to respond to this item. Thus, David not only produced gestures that adhered to the standards of his system, but he used his gestures to impose those standards on the gestures of others.

These examples are remarkable in that they indicate the distance David has achieved from his gesture system. It is one thing for a child to gesture to achieve a goal or make a comment, that is, to use gesture for a specific communicative act. It is quite another for the child to recognize that he is gesturing and to call attention to his gestures as communicative acts. David was able to treat other peoples' gestures as objects to be reflected on and, at times, corrected. Moreover, he

was able to distance himself from his own gestures and treat them as objects to be reflected on and referred to. He therefore exhibited in his self-styled gesture system the very beginnings of the reflexive capacity that is found in all languages and that underlies much of the power of language (cf. Lucy 1993).

The Challenge of a Nonshared System

The deaf children could have used gesture only for the basics—to get people to give them objects and perform actions. Indeed, when chimpanzees are taught sign language, the only purpose to which they seem to put those signs is to request objects and activities (Greenfield and Savage-Rumbaugh 1991). Request gestures are the easiest for others to interpret simply because context often makes it obvious what the child wants. But the deaf children do much more with their gestures. They use them to comment not only on the here and now but also on the distant past, the future, and the hypothetical. They use them to tell stories, to talk to themselves, and to talk about their own and others' gestures. In other words, they use them for the functions to which all natural languages are put. These functions are a challenge, not only for the children but also for the children's hearing parents.

The challenge for the children is to take the cospeech gestures that they see their hearing parents use and transform those gestures into a structured system that functions like language. In this regard, it is noteworthy that language structure and language function seem to go hand in hand in the deaf children's gesture systems, although the developmental relationship between the two is far from clear. For example, the functions to which the deaf children put their gestures could provide the impetus for building a languagelike structure. Conversely, the structures that the deaf children develop in their gestures could provide the means by which more sophisticated languagelike functions can be fulfilled. More than likely, language structure and language function complement one another, with small developments in one domain furthering additional developments in the other.

The challenge for the deaf children's hearing parents is to be able to interpret the children's gestures enough so that the two can communicate with one another without the benefit of a shared linguistic code (cf. Goodwin this volume). This challenge is made more serious by the fact that the parents have placed their children in oral training and do not particularly want them to be gesturing—they want their children to be learning to talk. As a result, the parents pay little conscious attention

to their children's gestures. Surprising as it may seem, gesture in the deaf children's homes is rarely acknowledged and, in this sense, is no different from the gestures that hearing children (and indeed all hearing speakers) produce along with their talk.

In the second part of this chapter, I explore the role that gesture plays in human interaction for individuals who know a conventional spoken language. Gesture may not be acknowledged, but it has an impact on communication nevertheless. Gesture often conveys information that is different from the information conveyed in speech and offers a window onto thoughts that do not fit neatly into the categories offered by conventional language (Goldin-Meadow and McNeill 1999). Gesture externalizes a speaker's unspoken thoughts and, as a result, is an important part of the multimodal repertoire that humans rely on when they interact with one another (see chapters by Hutchins and Goodwin this volume).

To explore the role that cospeech gesture plays in human interaction, I turn to the gestures that hearing children produce during a teaching interaction. The gestures children use when they explain their solutions to a problem often reflect an implicit understanding of the problem not fleshed out in their speech. Importantly, teachers are sensitive to the gestures children produce—they alter their instruction as a function of those gestures, providing input that has the potential to help the child develop a more articulated understanding of the problem. Gesture is (unwittingly) shared by child and teacher, and indeed by all speakers and listeners, and in this way extends the range of communication beyond the bounds of conventional language.

The Gestures we Produce when we Talk: Using Gesture to Distribute Cognition

We can Learn a Great Deal about Children's Knowledge from their Gestures

Gesture and speech encode meaning differently (Goldin-Meadow 2003a; McNeill 1992). Gesture conveys meaning globally relying on visual and mimetic imagery. Speech conveys meaning discretely relying on codified words and grammatical devices. Because gesture and speech employ such different forms of representation, it is difficult for the two modalities to contribute identical information to a message. Nonetheless, the information conveyed in gesture and in speech can overlap a great deal. For example, consider a child who utters the word "chair"

while pointing at the chair. The word labels and classifies the object. The point indicates where the object is (see Liszkowski this volume, for further discussion of the pointing gestures children use at the early stages of language learning). Although word and gesture do not convey identical information, they do work together in this example to more richly specify the same object.

However, there are instances in which gesture conveys information that overlaps very little with the information conveyed in the accompanying speech. Consider a child who says "daddy" while pointing at a chair. This child has produced a gesture for an object that is not mentioned in speech. Here, word and gesture convey information that does not overlap at all. Note, however, that taken together the two modalities convey a simple notion—"daddy's chair"—that is not conveyed in either modality on its own.

I have posited a continuum based on the overlap of information conveyed in gesture and speech (Goldin-Meadow 2003a). At one end of the continuum, gesture elaborates on a topic that has already been introduced in speech. At the other end, gesture introduces new information that is not mentioned at all in speech. Although there are times when it is not clear where to draw a line to divide the continuum into two categories, it turns out that most cases are obvious and relatively easy to identify. We have dubbed cases in which gesture and speech convey overlapping information "gesture–speech matches," and cases in which gesture conveys more information than speech "gesture–speech mismatches" (Church and Goldin-Meadow 1986).

As an example of a gesture–speech match in a school-aged child, consider the response given by a child asked to explain his incorrect solution to the mathematical equivalence problem, 7 + 6 + 4 = 7 + __. The child indicated that he solved the problem by adding up the numbers on the left side of the equation in both speech ("I added 7 plus 6 plus 4 and got 17") and gesture (point at the left 7, the 6, the 4, and the blank). As an example of a gesture–speech mismatch on this same problem, another child indicated in speech that she also solved the problem by adding up the numbers on the left side of the equation ("I added 7 plus 6 plus 4 and got 17"). However, in gesture, this child indicated all of the numbers in the problem (point at the left 7, the 6, the 4, the right 7), making it clear that she did, at some level, know that the 7 on the right side of the equation was there and might be important. Note that this second child seems to have an understanding (however implicit) of two pieces of information: (1) there are two distinct sides to the equation (reflected in the add-to-equal-sign strategy the child

conveyed in the speech component of her mismatch); (2) there is an additional addend on the right side of the equation (reflected in the add-all-numbers strategy she conveyed in the gesture component of her mismatch). These two pieces of information are not yet integrated into a single framework but eventually will have to be if the child is to solve the problem correctly.

Children who produce mismatches in their explanations of a task have information relevant to solving the task at their fingertips and could, as a result, be on the cusp of learning the task. If so, they may be particularly susceptible to instruction. To explore this hypothesis, we gave nine- to ten-year-old children instruction on problems of the $4 + 5 + 3 = \_\_ + 3$ variety. Prior to instruction, all of the children solved the problems incorrectly and all of their spoken explanations were incorrect. However, the children differed with respect to their gestures: Some produced gestures that did not match their speech, whereas others produced matching gestures. After the instruction period, we gave the children a second test to see how much they learned. We found that children who had produced mismatches prior to instruction were more likely to profit from instruction than children who had produced no mismatches (Perry et al. 1988; see also Alibali and Goldin-Meadow 1993). To test the generality of this finding, we conducted a comparable study with five- to eight-year-old children using a different task (reasoning about quantity) and found once again that children who produced mismatches prior to instruction were more likely to profit from instruction than children who produced matches (Church and Goldin-Meadow 1986)—they were ready to learn. Gesture–speech mismatch can serve as an index of a child's readiness to learn a particular task. Moreover, because the gestures in a mismatch convey substantive information that is *not* found in speech, mismatches provide insight into children's newest and not-yet-digested notions, notions that their teachers might want to consider teaching next.

Teachers can take Advantage of the Information Conveyed in a Child's Gestures

Gesture–speech mismatches are not limited to a particular age or task, nor are they characteristic of particular individuals. Moreover, gesture–speech mismatch is not a personality trait—the same child who produces many mismatches on one task can produce none on another (Perry et al. 1988). Gesture–speech mismatch indicates when a particular child is ready to profit from instruction on a particular task. In this way, gesture

offers information that could prove useful to teachers when instructing children. Can teachers take advantage of this offer?

To find out, we observed eight teachers instructing children individually in the concept of mathematical equivalence (Goldin-Meadow and Singer 2003). As we now would expect, the children's gestures often revealed knowledge that they did not seem to know they had. Consider, for example, a child explaining how he solved the math problem 4 + 5 + 3 =__ + 3. The child said, "I added 4 plus 5 plus 3 plus 3 and got 15," demonstrating no awareness that this is an equation bifurcated by an equal sign. His gestures, however, offered a different picture: He swept his left palm under the left side of the equation—paused—then swept his right palm under the right side. His gestures clearly demonstrated that, at some level, he knew that the equal sign breaks the string into two parts. The question we asked was whether teachers offer a different type of instruction to children who produce gesture–speech mismatches than to children who do not.

The answer is "yes." The teachers gave more variable instruction to children who produced mismatches than to children who produced no mismatches in two respects (Goldin-Meadow and Singer 2003). (1) They presented more different types of strategies for solving the math problem in their instructions to children who produced mismatches than to children who did not. (2) They produced more of their own mismatches (i.e., more instructions containing two different strategies, one in speech and one in gesture) to children who produced mismatches than to children who did not. Most of the teachers' mismatches contained correct strategies in both gesture and speech. For example, on the problem 7 + 6 + 5 = __ + 5, one teacher expressed an equalizer problem-solving strategy in speech ("we need to make this side equal to this side") while conveying a grouping strategy in gesture (point at the 7, the 6, and the blank—the two numbers that give the correct answer if grouped and added together). Both strategies lead to correct solutions yet do so via different routes.

Teachers use their students' gestures to discover the thoughts those students are unable to express in words, and they then change their instruction in response. The question I turn to next is whether the instruction that teachers spontaneously give children who are on the cusp of change actually promotes learning.

Teachers' Gestures can Promote Learning

The teachers in our math study increased the number of gesture–speech mismatches they produced when teaching children who themselves

produced mismatches, and the mismatching children profited from the instruction (Goldin-Meadow and Singer 2003). However, these children were ready to learn the math task—any type of instruction on the problem might have resulted in improvement in mismatching children. To determine whether the teachers' instruction per se had a hand in learning, we needed to manipulate instruction.

We gave nine- and ten-year-old children who did not know how to solve mathematical equivalence problems instruction that was modeled after the instruction the teachers had spontaneously used in our naturalistic study (Singer and Goldin-Meadow 2005). Children were taught either one or two problem-solving strategies in speech accompanied by no gesture, gesture conveying the same strategy, or gesture conveying a different strategy. We found that children were indeed likely to profit from instruction with gesture, but only when the gesture conveyed a different strategy from speech. Moreover, two strategies were effective in promoting learning only when the second strategy was taught in gesture, not speech.

The teachers were right—instruction in which gesture and speech convey different information is indeed good for learning. It is unlikely, however, that the teachers in our study were consciously aware of how they used their hands to promote learning, nor is it likely that the children were consciously aware of using their hands to display their knowledge. Gesture provides an undercurrent of conversation that takes place alongside the acknowledged conversation in speech. Although not explicitly recognized, this under-the-surface conversation is influential. Why?

Gesture provides a second representational format for presenting ideas, one that has a strong visual component. In this sense, gesture is like a diagram, physical model, or map—artifacts of the society that can also play a role in structuring communication and thinking (Goodwin, and Hutchins in this volume). Gesture is unique, however, in that unlike a map or a diagram, it is transitory—disappearing in the air just as quickly as speech. But gesture also has an advantage—it can be, indeed *must* be, integrated temporally with the speech it accompanies. And we know that it is important for visual information to be timed appropriately with spoken information for it to be effective (Baggett 1984; Mayer and Anderson 1991). Thus, gesture used in conjunction with speech may present a more naturally unified picture to the student than a diagram used in conjunction with speech. And because the two ideas presented in a mismatch (one in speech and the other in gesture) are temporally unified, the contrast between them may be particularly salient, and as a result, may catalyze change.

It is clear that gesture is part of the complex multimodal interaction system that characterizes human interaction. But what role does it play? Hutchins (this volume) suggests that we must choose between gesture being (1) an external expression of an internal representation *or* (2) part of the multimodal interaction system that is itself thinking. My own view is that this is an *and* not an *or* situation. In the math tutorial I described, learning how to solve the problem correctly was a joint activity shared by child and teacher, one in which both participants' hands played a contributing role (akin to the navigation example Hutchins describes in which the crew gestured imaginary lines of position and then used those gestures as a framework for coming to an agreement about the ship's position). This is an instance of gesture being part of what Hutchins calls the thinking process. However, the child's gestures, even before instruction, were not empty movements waiting for meaning to be supplied by the teacher. Consider the child who pointed at all four numbers (the add-all-numbers strategy) while saying that he added the 7, 6, and 4 to solve the problem 7 + 6 + 4 = 7 + __. Hutchins's view would lead us to hypothesize that this child does *not* have an internal representation of the add-all-numbers strategy, as the strategy was expressed in gesture but not in speech. But we can show that this child does indeed have at least an implicit awareness of the add-all-numbers strategy—the child will judge 24, the solution one gets if all of the numbers are added together, to be an acceptable answer to the 7 + 6 + 4 = 7 + __ problem (Garber et al. 1998). Gesture is not a meaningless activity for the gesturer. Indeed, I suggest that it is because gesture reflects the speaker's internal representations that it can serve as part of the process that leads to change in those representations.

The ideas that gesture externalizes are often incompletely thought out. These incomplete ideas, once externalized, can become more complete as a result of being operated on by others, as the math tutorial and navigation examples illustrate. But the nascent ideas that speakers express in gesture can also become more complete as a result of being operated on by the speakers themselves (e.g., gesture could serve as a cognitive prop allowing the child to think through the math problem with greater ease; cf. Goldin-Meadow and Wagner 2005). There are several ways in which ideas can come into being as a function of being expressed in gesture.

Meeting Other Minds through Gesture

Although rarely acknowledged in the course of conversation, gesture is always "out there." Gestures are concrete manifestations of ideas for all the world, not only the world of education, to see. Speakers produce gestures that reveal to their listeners thoughts that are not apparent in their speech. And listeners produce gestures that, in turn, have an impact on the message their partner takes from the conversation. Hands play an important role in our conversations.

Gesture is unacknowledged in the two communication situations I have considered here. It nevertheless has a clear impact on conversation in both (indeed, for the deaf children, it is the conversation). When called on to accompany speech, gesture functions along with speech without assuming its linguistic form and contributes to the give and take between speakers and listeners. When called on to substitute for speech, gesture takes over both the forms and the functions of language and, again, is responsible for the give and take between participants (although the exchange is less symmetrical—the deaf children give out linguistic gesture but take in cospeech gesture, and the hearing parents do the reverse). Both phenomena underscore the fact that conventional language does not dictate communication—that the urge and capacity to interact and communicate does not depend on a shared system passed down from generation to generation.

Indeed, even when raised without access to conventional language but in the company of other people, human children spontaneously use their hands to communicate. And the hand gestures they invent are used not only to make requests but, more strikingly, to share their thoughts with others. Although many animals have complex social lives and intricate systems of communication, no other animal society has a communication system that is used just to share ideas—to tell stories, to talk to oneself, to talk about talk. The need to interact with others in a symbolic way appears to be a basic human trait, one that is difficult to inculcate in other animals and equally difficult to repress in human children.

Acknowledgment

This research was supported by grants from the National Institute of Deafness and Other Communicative Disorders (R01 DC00491), the National Institutes of Child Health and Human Development (R01 HD47450), and the Spencer Foundation.

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