Beyond Words: The Importance of Gesture to Researchers and Learners

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Gesture has privileged access to information that children know but do not say. As such, it can serve as an additional window to the mind of the developing child, one that researchers are only beginning to acknowledge. Gesture might, however, do more than merely reflect understanding—it may be involved in the process of cognitive change itself. This question will guide research on gesture as we enter the new millennium. Gesture might contribute to change through two mechanisms which are not mutually exclusive: (1) indirectly, by communicating unspoken aspects of the learner's cognitive state to potential agents of change (parents, teachers, siblings, friends); and (2) directly, by offering the learner a simpler way to express and explore ideas that may be difficult to think through in a verbal format, thus easing the learner's cognitive burden. As a result, the next decade may well offer evidence of gesture's dual potential as an illuminating tool for researchers and as a facilitator of cognitive growth for learners themselves.

INTRODUCTION

To accurately characterize what children know, it is often essential to look beyond what they say. When children are asked to explain their performances, their verbal reports may not capture all facets of their understanding. Some knowledge may be difficult to tap by traditional verbal response protocols (Ericsson & Simon, 1980, 1993). Other knowledge may simply be inaccessible to verbal report (Berry & Broadbent, 1984; Nisbett & Wilson, 1977; Reber, 1993; Stanley, Mathews, Buss, & Kotler-Cope, 1989).

How might we access children's unspoken knowledge? One potential source is nonverbal behavior. Nonverbal cues (facial expressions, eye contact, hand gestures, body movements) have traditionally been assumed to reflect speakers' feelings (Friedman, 1979) and, as such, have been studied in conjunction with children's emotional states. Recent work has greatly expanded our view of nonverbal behavior, however. Nonverbal behaviors—in particular, hand gestures—have been shown to convey substantive information and provide insight into speakers' mental representations (Goldin-Meadow, McNeill, & Singleton, 1996; Kendon, 1980; McNeill, 1985, 1987, 1992). For example, McNeill (1987) has found that speakers use hand gestures to depict both concrete images (e.g., actions or attributes of cartoon characters) and abstract concepts (e.g., mathematical concepts, such as quotients, factors, and even limits in calculus).

Perhaps more surprising, hand gestures can transmit information that is not conveyed anywhere in talk. For example, consider a child explaining how she solved the mathematical problem $4 + 5 + 3 =$ ___ $+ 3$. The child says, "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. Her gestures, however, offer a different picture: she sweeps her left palm under the left side of the equation, pauses, then sweeps her right palm under the right side, clearly demonstrating that at some level she knows the equal sign breaks the string into two parts (Perry, Church, & Goldin-Meadow, 1988). If a child's gestures consistently reflect knowledge that the child possesses but does not verbalize, then gestures—which are pervasive, overt, and interpretable—could be a potentially rich source of information about unspoken knowledge.

I begin by briefly reviewing the evidence that gesture has privileged access to information speakers know but do not express in words. I argue that gesture is an important window to the mind, one that researchers ignore at their peril. However, gesture was not put on earth to serve experimenters. Gesturing is a widespread and robust phenomenon, occurring across ages, tasks, and cultures (Feyereisen & Lannoy, 1991). Even congenitally blind individuals who have never seen gesture use it when talking to blind listeners (Iverson & Goldin-Meadow, 1997, 1998). What purpose do these gestures serve?

There is growing evidence that gesture not only reflects understanding but shapes it, playing a role in the learning process itself.[1] I suggest that this hypoth-

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[1] Gesture has the potential to contribute not only to our understanding of change on the ontogenetic timespan, as developed here, but also to our understanding of change on shorter timespans (e.g., how information is processed during the act of speaking; de Ruiter, 1998; Kita, 2000; McNeill, 1992) and longer timespans (e.g., how language itself evolved; Donald, 1991; Goldin-Meadow & McNeill, 1999; Hewes, 1973).

esis will guide research on gesture as we enter the new millennium. Gesture could serve as a mechanism for change in two ways which are not mutually exclusive:

1. Gesture might play an indirect role in the learning process by displaying, for all to see, the learner's newest, and as yet undigested, thoughts. Parents, teachers, and peers would then have the opportunity to react to those unspoken thoughts and provide the learner with input necessary for future gains. Thus, on one path researchers will take in the new millennium, they will explore gesture's role in dyadic communication and, in the process, gain insight into the interplay between speaker and hearer at a more general level.

2. Gesture might play a more direct role in the learning process by providing another representational format in addition to speech. Serving as a "cognitive crutch," gesture could allow the learner to explore—perhaps with less effort—ideas that may be difficult or inappropriate to think through in a verbal format. On the second research path leading into the future, scientists will therefore explore gesture's role in the thinking process itself.

WHAT HAS GESTURE TAUGHT RESEARCHERS?

Gesture Conveys Task-Relevant Information

Although they may appear to be mere hand-waving, the movements speakers make with their hands as they talk are systematically related to the words they utter (McNeill, 1992). What is the evidence that gesture is a medium through which speakers convey their knowledge? The first step is to show that gesture can be interpreted reliably and consistently. A substantial number of investigators have observed the spontaneous gestures that adults and children produce along with speech in conversations (Kendon, 1980), narratives (McNeill, 1992), descriptions of objects and actions (Goldin-Meadow et al., 1996), and explanations in classrooms (Crowder & Newman, 1993) and in tutorials (Church & Goldin-Meadow, 1986; Evans & Rubin, 1979; Perry et al., 1988). The gestures produced in these situations can be assigned meanings and, most importantly, independent observers tend to assign the same meaning to the same gesture.

The second step is more direct. There is evidence that the meanings experimenters assign to a child's gestures are the meanings the child intends. Children were asked to complete an *explanation task* in which they ex-

plained their solutions to a set of math problems and, later, a *rating task* in which they judged solutions to a second set of problems. If gesture is a vehicle through which children express their knowledge—and if an experimenter can correctly assess this knowledge when attributing procedures to children based on their gestures in the explanation task—then, on the rating task, children should judge procedures they expressed in gesture on the explanation task as more "acceptable" than procedures they did not express at all. Children were found to do just that—even when those procedures were expressed *only* in gesture and not anywhere in speech (Garber, Alibali, & Goldin-Meadow, 1998). In addition to underscoring an important methodological point (that experimenters' interpretations of children's gestures are valid), these findings confirm an important conceptual point—that children's gestures are not random movements but rather reveal substantive beliefs about the task at hand.

Gesture Can Convey Information That Is Not Conveyed in Speech

People at times produce gesture that conveys different information from the information they convey in speech. These responses have been labeled "mismatches." Gesture–speech mismatch is a widespread phenomenon. It occurs in many cognitive tasks and over a large age range: in toddlers experiencing vocabulary spurts (Gershkoff-Stowe & Smith, 1997); preschoolers explaining games (Evans & Rubin, 1979); elementary school children explaining mathematical equations (Perry et al., 1988) and seasonal change (Crowder & Newman, 1993); children and adults discussing moral dilemmas (Church, Schonert-Reichl, Goodman, Kelly, & Ayman-Nolley, 1995); adolescents explaining Piagetian bending-rods tasks (Stone, Webb, & Mahootian, 1991); and adults explaining gears (Perry & Elder, 1996; Schwartz & Black, 1996) and problems involving constant change (Alibali, Bassok, Olseth, Syc, & Goldin-Meadow, 1999).

When children produce a gesture–speech mismatch in their "after-the-fact" explanations, they are expressing two distinct ideas, one in speech and one in gesture. Do children who produce mismatches in their post hoc explanations of a problem also activate two ideas when solving that problem on-line? The evidence suggests that they do (Goldin-Meadow, Nusbaum, Garber, & Church, 1993). Mismatchers activate more than one idea, not only when explaining a math problem, but also when solving that same type of math problem. The cognitive state that underlies mismatch thus involves having, and activating, two ideas on one task.

Gesture Taken in Relation to Speech Indexes Readiness-to-Learn

Utterances in which gesture and speech convey different information are not exclusive to a particular age or task, nor are they characteristic of particular individuals. The same child who produces many mismatches on one task may produce none on another (Perry et al., 1988). Gesture–speech mismatch is, however, characteristic of children in transition with respect to a given task. Two types of evidence support this claim.

1. Children who produce a large proportion of gesture–speech mismatches when explaining their (incorrect) solutions to a task are reliably more likely to benefit from instruction on that task than are children who produce few mismatches. This phenomenon has been found in conservation (Church & Goldin-Meadow, 1986) and mathematical equivalence (Perry et al., 1988). Mismatch marks a learner as being open to instruction and, in this sense, in transition.
2. In acquiring a concept, children progress from a stable state in which they produce incorrect gesture–speech matches, through an unstable state in which they produce gesture–speech mismatches, to another stable state in which they produce now correct gesture–speech matches (Alibali & Goldin-Meadow, 1993). Interestingly, the few children who skip mismatch and go directly from incorrect to correct match do reliably less well when tested later than those who pass through mismatch, suggesting that "skippers" do not truly master the concept. The mismatching state is an important step sandwiched between two matching states and is, in this sense, a transitional period.

Thus, children who produce a large number of mismatches are at risk with respect to learning. They are, however, also "at risk" for regression. The same proportion of children who would have progressed to a stable correct state if given instruction will, if given no instruction, regress to a stable *incorrect* state (Alibali & Goldin-Meadow, 1993). Mismatch indexes cognitive instability.

Gesture Has Privileged Access to Information at Certain Stages of Learning

When a child produces a gesture–speech mismatch, that child conveys information in gesture that is not found in the child's speech on that problem. Can this information be found in the child's speech on another problem? Or is it accessible *only* to gesture at this stage in the child's development?

When asked to solve a math problem, children apparently do produce procedures uniquely in gesture (i.e., not expressed anywhere in their speech), and mismatchers produce significantly more procedures in gesture only than do matchers (Goldin-Meadow, Alibali, & Church, 1993). The two groups do not differ in number of procedures produced in both gesture and speech and, interestingly, neither group produces many procedures in speech alone. These findings have two implications: (1) mismatchers produce more different procedures overall than do matchers, resulting in more variability in their problem-solving repertoires; (2) most of the "extra" procedures that mismatchers have in their repertoires are expressed *only* in gesture and not in speech; mismatchers possess knowledge that they seem unable to verbalize but can express in gesture.

Thus, the variability that many theorists consider essential to developmental progress (e.g., Bertenthal, 1996; Siegler, 1994; Thelen, 1989) is indeed present in children who mismatch. Importantly, this variability can only be detected by looking at the children's hands, not by listening to their words.

THE FUTURE OF GESTURE RESEARCH

One of gesture's most salient features is that it is "out there," a concrete manifestation of ideas. As such, gesture has the potential to contribute to the process by which speakers and hearers exchange ideas during communication. But gesture is not produced only when others are watching. How often have you found yourself gesturing while on the telephone, unseen by your listener? Gesture may serve a function for the speaker, perhaps contributing to the thinking process itself. These are two paths gesture research will pursue in the new millennium—exploring gesture's roles in communication and in thinking. By pursuing these paths we can discover how gesture contributes to cognitive growth.

Gesture's Role in Communication

According to the theory of communication developed by Sperber and Wilson (1986) in their book *Relevance,* all communicators need do to convey a thought is give their listeners appropriate evidence of their intention to convey that thought. Behavior capable of revealing a mental state can communicate the state if that behavior is used ostensively; that is, if it is displayed so as to make manifest an intention to inform the listener of the state (Sperber & Wilson, 1998, pp. 189–190).

Gesture presents an interesting case. Gesture

clearly can reveal mental states. But is it produced with the intent to inform a listener? Gesture can, of course, be used deliberately, as when speakers produce the "thumbs-up" emblem (Ekman & Friesen, 1969). But gesture is typically not under conscious control when it spontaneously accompanies speech. Speakers are often not even aware that they move their hands, let alone how they move them. Consider the child described earlier who indicated with her hands, but not with her words, that the math problem was bifurcated at the equal sign. It is not at all clear that the child intended to convey this knowledge to the listener, or even that the child was herself aware of having the knowledge. If, in fact, the message that the child consciously intended to convey did *not* include bifurcation at the equal sign, one might conclude that this information was not part of the communication.

However, the child did reveal this knowledge while speaking. Speaking is a deliberate act that makes manifest an underlying intention. Ostensive behaviors—including gesture—that co-occur with speech may also be relevant to that intention (cf. Sperber & Wilson, 1986, p. 49). If listeners assume that all properties tightly tied to an act of speaking are relevant to that act, then the knowledge displayed in gesture becomes a legitimate component of the database that listeners can use to infer the speaker's message. By being part of the act of addressing someone, gesture becomes relevant to the intended message.

Listeners might, under this view, get themselves into trouble with speakers, precisely because speakers may not be aware of the relevance their ostensive gestures have to their intended message. Imagine, for example, that the speaker says he didn't see your new sweater on the table while clearly indicating with his hands precisely where on the table the sweater had been. If you, as listener, were to then call him on the information conveyed in his hands, he might be taken aback (having forgotten, or perhaps not realized, that he saw the sweater). The information conveyed in gesture may not be conscious knowledge, but it is knowledge that speakers have—at some level. If confronted with the fact that their hands provide evidence of that knowledge, they may begin to develop a more explicit understanding of the knowledge (i.e., they may begin the process of "redescribing" it in another, more accessible format; cf. Karmiloff-Smith, 1992). It may, in fact, be an effective teaching technique, or an effective technique for clinical practice, to make explicit the information that a speaker conveys uniquely in gesture. Future work is needed to explore these possibilities.

Is gesture produced deliberately? Another direction for future research is to explore whether gestures that routinely accompany speech are indeed deliberate.[2] One could imagine, for example, that gesture has privileged access to implicit knowledge only when the speaker is unaware of gesturing. This hypothesis can be tested by asking children to consciously gesture while explaining a task. If, after this instruction, children no longer convey information that they previously revealed in gesture, we would suspect that gesture reveals a speaker's unspoken thoughts *only* when it is not deliberate—and that under normal circumstances gesture is *not* intentional. Another approach might be to vary the conditions under which talk is produced (e.g., putting opaque barriers between speakers and listeners) to determine whether speakers alter their gestures accordingly (cf. Cohen & Harrison, 1973). Of course, as argued above, whether gesture must be deliberately produced in order to convey information to others is an open question.

Does gesture communicate information to listeners not trained to code gesture? This question has received a fair amount of attention over the last several years but remains as yet unsettled. Krauss, Morrel-Samuels, and Colasante (1991) argue that the information listeners glean from gesture, above and beyond what is gleaned from the accompanying speech, is minimal at best. In this study, however, Krauss et al. use stimuli in which gesture conveys the same message as speech. One might imagine that gesture has its greatest impact on communication not when it conveys the same information as speech (i.e., gesture–speech matches), but when it conveys different information from speech (i.e., gesture–speech mismatches).

Indeed, in a variety of experimental studies, researchers find that adults and children who have not been trained to code gesture can glean substantive information from gesture when it conveys different information from speech (Alibali, Flevares, & Goldin-Meadow, 1997; Goldin-Meadow, Wein, & Chang, 1992; Kelly & Church, 1997; McNeill, Cassell, & Mc-

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[2] It is worth noting that, when gesture is deliberately produced in order to fulfill the functions of language, it changes form. When produced along with speech, gesture assumes an imagistic and global form (McNeill, 1992). However, when called upon to carry the full burden of communication, the manual modality assumes the discrete and segmented forms typically found in speech. This transformation occurs over a number of timespans (Goldin-Meadow et al., 1996): historical time (e.g., sign languages developed by deaf cultures); ontogenetic time (e.g., gesture systems invented by deaf children lacking exposure to sign language); and momentary time (e.g., gestures produced on the spot by hearing individuals asked to use their hands and not their mouths to communicate). It is only when gesture is *explicitly* called upon to communicate information that it takes on the forms of language (Goldin-Meadow et al., 1996).

Cullough, 1994; Thompson & Massaro, 1994). For example, consider a child in a number conservation task who said "they're different because you moved them," but in gesture matched the checkers in the two rows in a one-to-one fashion. When asked to assess this child's understanding, adults mention reasoning based on one-to-one correspondence—which appeared only in the child's gesture—as well as reasoning based on moving the checkers, which appeared in the child's speech. Listeners can even read gesture in "live" situations where gesture is not preselected and seen only once (Goldin-Meadow & Sandhofer, 1999).

In these studies, listeners are observers of the conversation, not participants in it. Future work will need to explore gesture's role in the give-and-take interplay between speakers and hearers in naturalistic situations. As an example of the kind of studies that are needed, one could ask teachers to instruct children individually, with no set script for each interaction. The goal would then be to observe how teachers and children respond to each spoken and gestured message that their partner produces. In a study of math tutorials with this design, we are currently finding that children do reproduce problem-solving procedures (even incorrect ones) that their teacher expresses uniquely in gesture (Goldin-Meadow, Kim, & Singer, 1999), and that teachers do the same when responding to a child. Future research needs to explore whether messages encoded in gesture enter into the conversation when different topics and different participants are involved.

Interestingly, when explicitly asked to describe a child's understanding of math problems, teachers seem bound in their own words by what the child says and puts in the blank. But the teachers' gestures make it clear that they do "read" child gesture, and know the child is entertaining additional thoughts. There is an unacknowledged exchange of ideas taking place that would not be captured by an audiorecorder. How widespread is this phenomenon? Would it help to make teachers aware of their own and their students' gestures? It is widely recognized that gesture occurs routinely in teaching situations. Another task for the future is to determine how gesture can best be harnessed to improve communication in classrooms.

Gesture does not have a demonstrable effect on listeners every time it is produced. In our paradigms, it typically affects the listener's response 30 to 40% of the time. One important question is whether one can determine when gesture will be "read," and when it will not. It is likely that the clarity of gesture will be a factor, but attributes of speech, context, and the listener's ability to entertain nonverbal information may also play a role. This issue is particularly signifi-

cant in situations where speakers may not be aware of the messages they convey, situations such as clinical therapy sessions in which patients may reveal through gesture ideas that they do not have conscious control over, or legal interviews in which children reveal through gesture knowledge that they do not know they have. The knowledge conveyed in gesture is there for the taking and, in certain circumstances, it may behoove us to take it and acknowledge its source.

Is comprehension of speech affected by the gestural company it keeps? If gesture is interpretable, it has the potential to influence comprehension of the speech it co-occurs with. If gesture conveys the same information as speech, it may facilitate comprehension of that speech. Conversely, if gesture conveys different information from speech, it may hinder comprehension of the speech. Indeed, in teacher–child math tutorials, children are *more* likely to repeat a problem-solving procedure a teacher produces in speech if that speech is accompanied by a matching gesture than if it is not accompanied by gesture, and they are *less* likely to repeat a procedure produced in speech if that speech is accompanied by a mismatching gesture than if it is not accompanied by gesture (Goldin-Meadow et al., 1999).

McNeill (1992) has argued that gesture and speech form an integrated system for *speakers.* Before the communication unfolds, gesture and speech are part of a single idea. As expression proceeds, the message is parsed into the two channels. Do gesture and speech also form an integrated system for *listeners*? Our findings suggest that they may. Understanding a message involves interpreting not only the words speakers utter but also their gestures. At present, it is rare, but not unheard of (e.g., Clark, 1996; Goodwin, 1981; Schlegoff, 1984), for researchers to attend to both modalities. Yet it is essential to do so. The challenge for the new millennium is to understand communication, not only in experimental contexts, but more importantly in naturalistic contexts—contexts in which words are only one among many cues to the speaker's message (Bloom, 1997; Clark, 1996; Sperber & Wilson, 1986).

Does dyadic gesture play a role in cognitive change? To summarize thus far, gesture conveys information not only to well-trained coders who have the advantage of instant replay, but also to naive listeners, both adults and children. This is one way gesture can contribute to cognitive change. Gesture routinely accompanies the speech children hear (even teachers' speech; Goldin-Meadow et al., 1999), and thus provides input that researchers typically ignore, but children may not.

But gesture can also play a more subtle role in fa-

cilitating cognitive change. Gesture can signal to parents and teachers that a particular notion is already in a child's repertoire, but not quite accessible. These listeners can then alter their behavior accordingly, perhaps giving explicit instruction in just these areas. In this way, children may be able to shape their own learning environments just by moving their hands. Note that if gesture does pinpoint those areas in which a child is ready to learn, it is functioning as an externalized index of the child's "proximal zone" (Vygotsky, 1978). Vygotsky suggested that for every task children possess a range of skills on which they can make progress if given appropriate assistance (the proximal zone). Effective education should teach to those skills, as they are the skills that are "ripe" for development. The puzzling question has always been, how can a listener identify a child's proximal zone, particularly in interactions not designed to test the child's knowledge? The spontaneous gestures children produce on-line as they tackle problems may provide one solution to this puzzle.

Adults seem to be able to pick up on the information that children convey uniquely in gesture. But do they make use of this information in their interactions with children? This is a question for future work, although anecdotal evidence hints that the answer may be yes. For example, when explaining the problem $5 + 3 + 4 = \_\_\_ + 4$, a child pointed simultaneously at the left and right 4's. The teacher responded, "you can solve the problem by adding the 5 and the 3 and putting the sum in the blank." Note that this "grouping" procedure works only because there are two 4's, one on each side of the equation, that can be canceled. The teacher had not suggested grouping earlier, and seemed to choose this moment to introduce the procedure because of the child's gesture. Moreover, the instruction proved effective: the child began using grouping for the first time, and continued to do so for the rest of the lesson.

This example raises an important point: listeners need not be aware of gestures in order to use to them. There is no evidence that this teacher knew she was reacting to the child's gesture. Indeed, if asked, she might not be able to articulate a reason for introducing grouping at this moment. Gesture allows an undercurrent of conversation to take place below the surface of awareness. Whether listeners make this undercurrent explicit, that is, whether they "translate" the information a speaker expresses uniquely in gesture into their own speech (as they do in conservation, Goldin-Meadow et al., 1992, but not apparently in math, Alibali et al., 1997) may vary systematically across listeners and across contexts, and is an area ripe for future research.

Gesture's Role in Thinking

Does gesturing enhance cognitive capacities? Current work suggests that gesturing may reduce cognitive effort, perhaps in the same way that writing a problem down reduces effort needed to solve the problem (see Alibali & DiRusso, 1999, who make this argument with respect to pointing and learning to count, and Rauscher, Krauss, & Chen, 1996, who argue that gesture facilitates the retrieval of words from memory). Does gesturing on one task (explaining a math problem) free up effort that can then be used on another task (recalling a list of words)? Preliminary findings (Goldin-Meadow, in press) suggest that children remember more words when they gesture than when they do not. Are these effects limited to certain types of domains—the spatial domain, for example, which the manual modality is particularly well suited to portray—or are they more general? And are these effects limited to gesture *production*? Having a message displayed in both gesture and speech may also ease the *listener's* cognitive burden (e.g., listeners might remember more items on a second task when decoding, on the first task, a message with gesture versus one without gesture).

How does gesturing increase resources? Gesture may have an effect on working memory, which plays a role in reasoning (Baddeley & Hitch, 1974). Baddeley (1986, 1992) suggests that there are two working memories, one that holds verbal material and one that holds visual or spatial material. By exploiting the visual modality and spatial representation (rather than verbal-propositional representation), gesture may facilitate a trade-off of information between these memories. Gesturing on a math task that has spatial components may allow children to encode into their visuospatial representations information that without gesture would have been encoded in verbal form. Unencumbered by those aspects of information that have been shifted into visuospatial memory, the verbal working memory is then less taxed and can accommodate more words in a simultaneously performed word-recall task. Note that if gesture enhances recall by encoding information into visuospatial working memory, then under certain circumstances gesture might hinder rather than facilitate recall. If, for example, children were asked to perform a spatial rather than a verbal recall task along with the math task, they might recall fewer spatial items when gesturing than when not gesturing. These questions are important to pursue as they will establish the conditions under which gesturing does (and does not) enhance cognitive capacities and, in the process, advance our understanding of the mechanisms underlying thought.

Does gesturing contribute to cognitive growth? If gesture does serve as a kind of "cognitive prop," the effort saved by gesturing could be allocated toward working out new ideas which could, in turn, lead to progress in the task. Gesture could, however, also contribute to cognitive change by itself providing a route through which learners bring in new information. For example, in science lessons, children frequently use gesture to foreshadow ideas they themselves eventually articulate in speech (Crowder, 1996), perhaps needing to express those ideas in gesture prior to expressing them in words. Because the representational formats underlying gesture are mimetic and analog rather than discrete, gesture permits the learner to represent ideas that lend themselves to these formats (e.g., shapes, sizes, spatial relationships), and that are not developed enough to be encoded in speech. Consider, for example, a speaker who is describing, or attempting to memorize, the coastline of the east coast of the United States. One well-formed gesture can do more to convey the nuances of the coastline to a listener, *or* to the speaker, than even the best chosen words (cf. Huttenlocher, 1976).

Gesture thus allows speakers to convey thoughts that may not easily fit into the categorical system that their conventional language offers (Goldin-Meadow & McNeill, 1999). McNeill (1992) argues that gesture and speech form complementary components of a single integrated system, with each modality best suited to expressing its own set of meanings. Gesture reflects a global-synthetic image. It is idiosyncratic and constructed at the moment of speaking—it does not belong to a conventional code. In contrast, speech reflects a linear-segmented, hierarchical linguistic structure, utilizing a grammatical pattern that embodies the language's standards of form and drawing on an agreed-upon lexicon of words. Taken together, gesture and speech offer the possibility of constructing multiple representations of a single task. These multiple perspectives may prove useful, particularly in domains that lend themselves to visual thinking (e.g., mathematics; Hadamard, 1945). Future research will explore whether gesture contributes the learner's newest and most advanced ideas to these multiple representations, and whether it does so in all domains and at all ages.

In addition to more easily reflecting cutting-edge ideas, gesture may also have an advantage over speech in that these new ideas can be brought in without disrupting the current, acknowledged system. Because gesture is uncodified and less susceptible to cultural approbation (speakers are rarely criticized for their spontaneous gestures), it may be an ideal modality within which to work out notions that are wild, untamed, and inchoate. Not only are the notions conveyed in gesture likely to go unchallenged by *others*, but they are also likely to go unchallenged by the *self*. A speaker can "sneak in" an idea, perhaps an ill-formed one, in gesture that does not cohere well with the ideas expressed in speech. Gesture may be an ideal place to try out innovative ideas simply because those ideas do not have to fit.

Once having entered the child's repertoire, ill-formed ideas can begin to change the system. It may be necessary for learners to see their own gestures in order for change to occur. Alternatively, it may be sufficient to produce gesture without ever taking it in visually, a hypothesis that can be tested to some degree using blind speakers who never see their own gestures. By offering an alternative route in which developing ideas can be tried out and expressed, gesture may itself facilitate the process of change.

SUMMARY

Gesture provides a unique view of learners' thoughts, one that researchers have only recently begun to recognize. However, gesture may also be involved in cognitive change itself. It is this issue that will occupy researchers as they enter the new millennium. Gesture may contribute indirectly to cognitive growth by communicating "silent" aspects of the learner's cognitive state to potential agents of change. The pursuit of this hypothesis will bring with it a greater understanding of communication in general. Gesture may also contribute more directly to cognitive growth by easing the learner's cognitive burden. The pursuit of this hypothesis will enhance our understanding of the thinking process itself.

If gesture is causally involved in change, its effect is likely to be widespread. Gesture has been found to express substantive information in a variety of tasks and over a large age range. Some tasks that elicit gesture are likely to have components that are innate (e.g., number), whereas others have components that are not (e.g., a board game). The fact that gesture is found in both situations may mean that it has the potential to be involved in innately driven as well as non-innately driven learning—that is, to be a *general* mechanism of cognitive growth. The time is ripe to begin looking beyond children's words to the secrets that, until now, have been locked in their hands.

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