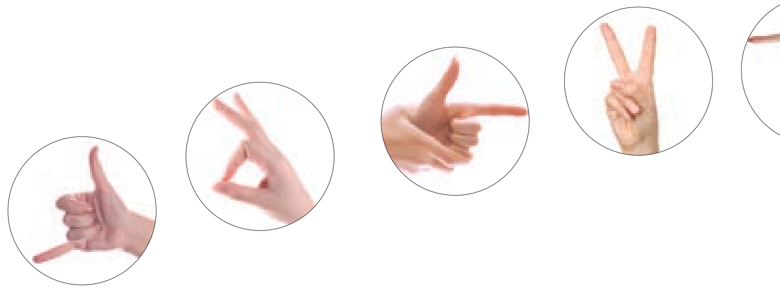
SPECIAL REPORT
Physical Education



Hands

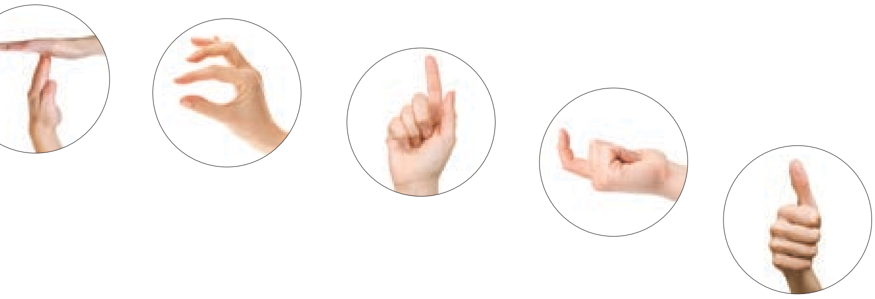
Gestures reveal subconscious

By Susan Goldin-Meadow

A teacher watches a fourth-grade student try to solve the equation 4 + 3 + 6 = __ + 6. The child pencils 13 in the blank. "How did you get that answer?" the teacher asks. "I added the 4 and the 3 and the 6 and got 13," the child replies. But as the child is talking, he holds one hand under the 6 on the left and the other hand under the 6 on the right, indicating that the child has, at least implicitly, noticed the 6s on both sides of the equation. Thus, the teacher realizes, it is a small mental leap to see that these equal numbers would cancel each other out and that the remaining numbers on the left can be added to get the correct answer, 7. The teacher says, "A better way to solve the problem would be to add the 4 and the 3 and put that number in the blank." From then on, the child uses this grouping strategy to solve future problems.

In this interchange, which took place in my laboratory while my colleagues and I were conducting a study on gesture and learning, neither the teacher nor the student talked about the 6s. But the teacher saw a rep-

GETTY IMAGES (*main pair of hands*); ISTOCKPHOTO (*inset hands*)



in the Air

knowledge and cement new ideas

resentation of the two 6s in the student's gestures, prompting the explicit instruction about grouping. If the student had not gestured in this way, the teacher might have suggested a different method of tackling the problem that might not have been so effective.

We often use gestures when explaining a complex topic, but we also move our hands when simply chatting. These spontaneous hand movements are not random; they reflect our thoughts. Children who are on the verge of mastering a task advertise that fact in their gestures. Listeners glean information from these movements, often unconsciously. Good teachers change their instruction in response to a student's gestures, altering their explanations and even their own gestures. Children learn better from this kind of tailor-made instruction.

Children naturally shape their own learning environments just by moving their hands. But encouraging kids to use gestures while they learn can amplify the effect, bringing out their implicit knowledge and thus changing the way they approach problems and tasks. Kids master tasks faster, and they better remember how to do them when they move their hands. In this way, bringing gesture into the classroom can facilitate learning.

Deaf children who are not exposed to conventional sign language, which is depicted here, may invent their own communication systems using only their hands, representing different parts of speech with specific gestures.

SILKE WERNET *laif/Redux Pictures*

Portal to the Mind

Everyone gestures, moving their hands in synchrony with their words. These movements come in several varieties. In addition to pointing, we use our hands to pantomime actions—for example, rotating our fingers as though twisting open a jar—and to capture abstract ideas—say, moving a hand forward when talking about the future.

Gesturing is innate: people who have been blind since birth gesture, even though they have never seen anyone else do it. The fact that congenitally blind speakers move their hands when talking to other blind people suggests that we do not always gesture for our listeners. We also gesture for ourselves.

Gesturing is so natural that people often fail to notice that they are doing it. In some of our experiments, we avoid telling our subjects what we are really studying to avoid provoking self-conscious responses that might compromise the results. When the experiment is over, though, and we explain that we were examining their gestures, participants often apologize profusely for not having gestured—even though they gestured liberally throughout the study. People are often equally unaware of others' gestures, yet they nonetheless absorb the information and seamlessly integrate it into what they gather from the words they hear. Indeed, gesture may gain much of its power to influence how we think and learn from the fact that it remains covert.

I began investigating gesture as a result of my in-

FAST FACTS

Actions Speak Loudly

1» Congenitally blind people move their hands when talking, implying that we gesture not only for our listeners but for ourselves.

2» Common gestures include pointing, pantomiming actions and capturing abstract ideas by, say, moving a hand forward when talking about the future.

3» Children who are on the verge of mastering a task advertise this fact in their gestures.

4» Encouraging kids to use gestures can bring out their implicit knowledge and thus change the way they think.

Gesture may gain much of its power over how we think from the fact that **it remains covert.**

terest in the origins of language. Back in the 1970s, I studied deaf children who invented their own communication systems using only their hands, representing nouns, verbs and other parts of speech through specific gestures. To determine how much the deaf children's communication systems differed from the gestures that surrounded them, I needed to know what hearing people do with their hands when they speak. So, in the mid-1980s, I started examining gestures in hearing children as they were thinking and learning.

Gesture and nonverbal communication had long been considered a window onto people's moods and attitudes. By the time I took up the topic, psychologists such as David McNeill of the University of Chicago and Adam Kendon, now at the University of Pennsylvania, were starting to explore what gesture can tell us about how people think, as opposed to how they feel [see "Gestures Offer Insight," by Ipke Wachsmuth; Scientific American Mind, October/November 2006]. My colleagues and I followed this thread connecting gesture to thought. Our studies over the past 25 years link these characteristic hand motions to the emerging study of embodied cognition—the ways that knowledge and awareness are grounded in physical sensations and actions.

Mommy's Hat

In one of my first studies of gesture, in 1986, I watched kids as they tried to explain their answers to a popular conservation-of-matter question. In this problem, a demonstrator pours water from a tall, thin glass into a short, wide glass and asks, "Is the amount of water in the second glass the same as, more than or less than the amount that had been in the first glass?" Of course, the amount has to be the same, but many young children see that the water is at a lower level in the second glass and say that the amount has decreased. As we watched the children answer verbally, my colleagues and I noticed that they often also gestured.

To determine whether we could find meaning in those gestures, we videotaped the children and turned off the sound, separating the gesture from the speech. We also listened to the audio without watching the videotape, to focus on the speech. We found that, at times, the information we gleaned from the children's gestures was not the same as what they said. For example, a child might say that the amount of water had decreased when it was poured into the wider glass because "it's shorter," but his gestures—two hands shaped like C's, mirroring the width of the glass—would show that he knew, at some implicit level, that the width of the glass was also important.

Similarly, the student attempting to solve $4 + 3 + 6 = \_\_ + 6$ uttered the wrong answer, but by placing his hands underneath the two 6s, he indicated an awareness of a strategy that would lead to the right one. Such mismatches between gesture and speech occur in other contexts as well. They often capture a piece of knowledge of which the speaker is not fully aware. For example, toddlers who are just learning to talk may utter "Mommy" but point at a hat. This behavior does not mean that the toddler thinks Mommy is a hat. Instead the toddler is combining gesture and speech as if to say "Mommy's hat." In 2005 we reported that producing such gesture-speech combinations is a sign that the child is on the cusp of uttering his first two-word sentence. After observing children over time, we were able to predict that two or three months after a child produced her first gesture-speech combina-

Toddlers may combine gesture and speech to communicate more than they could with words alone. When a young child, say, points to an object such as a carrot but utters a noun such as "Tommy," he may be trying to say "Tommy's carrot."

GETTY IMAGES (*hands*); AGE FOTOSTOCK (*boy with carrots*)

(The Author)

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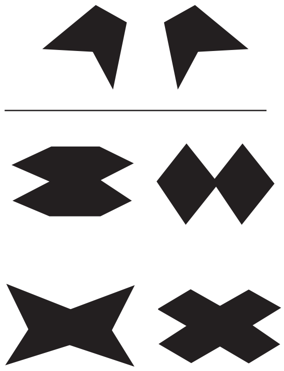

In one experiment, preschoolers were asked to mentally combine two shapes (*top*) to match one of four figures (*bottom*). (Correct match appears at the bottom left.) Children's gestures often indicated a better way of solving the problem than their words did.

tion, she would speak her first two-word sentence.

More generally, people whose gestures convey different information from their words are often on the verge of making progress on a task, whether that is an arithmetic problem, a leap in language development or a conceptual insight into the physical world. A person's gestures may represent an alternative way of tackling a problem than the one he or she is expressing in words. In one experiment, we asked preschoolers to mentally combine two pieces of a shape to determine which whole shape they matched. We found that some preschoolers would talk about the number of "points," or corners, the shape had—information that was largely irrelevant to solving the problem—but at the same time would produce a gesture illustrating how the pieces could be moved to fit one of the shape choices [*see illustration above*]. In this case, as in the addition problem described earlier, the gestures reveal a more pertinent strategy than the speech they accompanied.

In such instances, explicit instruction on how to solve a problem often brings rapid results; in fact, teaching tends to benefit students whose gestures differ from their speech more than those whose gestures and speech jibe. When we give instruction in the task to children who cannot solve a math problem or who do not yet understand conservation of matter, the children who produce gesture-speech mismatches of any type when trying to explain the material are the most likely to improve after instruction. The child in our math example was ready to receive advice on how to solve the equation, as were the preschoolers who talked about "points" but gestured about moving the pieces, and their gestures advertised that fact to anyone who was paying attention. In these receptive learners, instruction may serve to move the implicit knowledge conveyed in gesture to the forefront of consciousness, enabling it to trump erroneous or poorly formed ideas. Paying attention to the covert information in gestures can reveal which kids are ready to move on and which are not.

Cementing Memory

The act of gesturing not only reflects what people know but can, if deliberately encouraged, change the way they think—often for the better. Telling kids to gesture while they talk can speed learning. In a study published in 2007 psychologists Sara Broaders of Northwestern University and Susan Wagner Cook, now at the University of Iowa, along with Zachary Mitchell, then my research assistant, asked 70 third and fourth graders to solve a set of mathematical equivalence problems (such as 6 + 4 + 2 = __ + 2) twice. After all the students took a first crack at these problems, we told some of them to move their hands and the others to use just words, while they explained their answers. We then gave all the children a lesson in how to work out the problems and asked them to solve a new set of problems. Students who gestured prior to the lesson answered more problems correctly than did those who kept their hands still. Moving their hands helped the children learn the information presented in the lesson.

When we looked closely, we noticed that the children who gestured suggested new strategies with their hands that they had not previously expressed in words or actions. For example, one child pointed at the 6, the 4 and the 2 on the left and then produced a take-away gesture near the 2 on the right, illustrating an "add up all the numbers on the left and take away the number on the right" strategy. This knowledge remained dormant in the children who were not told to gesture, although we believe they must have had it, because all the children in our study solved and explained the problems in exactly the same way before the lesson. Thus, gesture not only reflects the presence of implicit knowledge but also can help bring it to the forefront of a child's

8 + 3 + 5 = __ + 5

Children taught to make a V with their fingers to "group" the two relevant numbers in problems such as this one got more right answers than did kids told to verbally explain how to solve the problem.

SOURCE: "EARLY SEX DIFFERENCES IN SPATIAL ABILITY," BY S. C. LEVINE, J. HUTTENLOCHER, A. TAYLOR AND A. LANGROCK, IN *DEVELOPMENTAL PSYCHOLOGY*, VOL. 35; 1999 (*shapes*); ANSSI RUUSKA *iStockphoto* (*fingers*)

mind, furthering his or her progress as a learner.

In addition to encouraging kids to gesture at will, teachers can also instruct children to produce specific gestures that capture particular concepts. In a study published in 2008, I found that instructing kids to produce particular gestures—as opposed to letting them make whatever gestures they want—helps kids remember what they learn. Before giving 84 third- and fourth-grade children a math lesson, Cook, Mitchell and I taught one group of children to say "I want to make one side equal to the other side" (the equalizer strategy) and to produce hand movements conveying that idea (sweep the left palm under the left side of the equation, then sweep the right palm under the right side of the equation). We told another group to repeat the words only and a third group to simply make the hand movements.

Then Cook taught the children to apply the equalizer strategy—using both gestures and speech—to a set of math problems of the same type. Before and after each problem, the children repeated the words or the gestures, or both. All of them solved the same number of problems correctly after the lesson, but when they were tested a month later using similar problems, only those who had gestured during the initial lesson continued to solve the problems correctly. (The nongesturers reverted to their old ways.) All that mattered was that children gesture: the kids who only gestured remembered as much as those who used both speech and gesture, suggesting that teaching children gestures tailored to a lesson—in this case, pantomiming a correct problem-solving strategy—can make learning last. Using the body to convey an idea appears to cement that idea in the child's repertoire.

Next we wondered whether a teacher could introduce an idea or strategy only by directing a student to produce appropriate hand movements—without any overt verbal instruction. In a study published in 2009 we taught children the equalizer strategy verbally but introduced a different strategy (grouping) only by suggesting certain hand move-

We gesture even when a listener cannot see us. Gesturing helps us think—in part, by bringing implicit or hidden knowledge to the front of our minds.

GETTY IMAGES (*hands*); MOTHER IMAGE/CULTURA/CORBIS (*girl on phone*)

Relevant knowledge remained dormant in the children who were not told to gesture.

Gesturing while talking could lighten the cognitive load of narrating anything complex.

ments. For the equalizer strategy, all the kids were taught to say "I want to make one side equal to the other side" when solving problems such as 8 + 3 + 5 = __ + 5. We told some of them to simply say these words. Others repeated the words and made hand movements that grouped two of the addends: for 8 + 3 + 5 = __ + 5, children made their first and middle fingers into a V and placed it under the 8 and the 3 [*see bottom illustration on page 52*]. Then they pointed at the blank with the same hand. To find out how much of the effect might be the result of just moving the hands, we asked a third group to recite the equalizer speech and use their hands to suggest grouping the wrong two numbers—making a V under the 3 + 5. In all cases, the teacher's verbal instruction referred to the equalizer strategy only.

Even though all the children talked about the equalizer method, the kids who gestured about the correct grouping strategy solved the most problems correctly. Perhaps even more encouraging, the kids who made a V under the wrong two numbers got more correct answers than did those who did not gesture about grouping at all—it seems that they had extracted some aspects of grouping from their partially correct gestures. Moreover, the gesturers who improved after the lesson suddenly began talking about grouping, indicating that the knowledge had become explicit even though the teacher had not talked or gestured about it. Thus, the children's ability to explain grouping after the lesson must have originated in their own gestures; they learned a new technique just by moving their hands in a particular way.

Making the Telling Easier

Gesturing may also aid learning by shouldering some of the cognitive burden. When a problem is hard, hand movements may accomplish some of the necessary "thinking," the way writing a problem down can make it easier to solve. My colleagues and I tested this hypothesis by assessing the effect of gesture on a problem designed to tap the same cognitive resources as memorizing a list of words. If gesture eased the mental effort, or cognitive load, needed to solve the problem, the act of gesturing should improve people's ability to remember the words.

In one of my team's studies, published in 2001, after giving children and adults a list of words to memorize, we told them to solve a math problem and to explain their solutions. For some of the problems (but not for others), participants gestured while they delivered their explanations. When the participants gestured, we found that they recalled more of the words on the list than when they did not—suggesting that gestures reduced the cognitive load of the math problem, leaving more brainpower available for remembering the words.

My colleague psychologist Raedy Ping and I found a similar effect of gesture on cognitive load more recently when we asked five- to seven-year-olds to explain their responses to the conservation-of-matter problem (the experiment mentioned earlier

Sleight of Hand

Gestures not only transmit accurate information but also can mislead. In a particularly striking example, we once noticed that a teacher's gestures inadvertently led a student to an incorrect strategy for solving a math equivalence problem. While verbally describing the correct strategy, the teacher pointed at all four numbers in the equation, a gesture the child read as an instruction to add up all the numbers in the problem. The child then put that sum in the blank.

Gestures can also bias witnesses. We know that a question such as "What color was the hat the man was wearing?" can sway a witness to state that the man in question was wearing a hat even if he was not. In a recently published study Northwestern University psychologist Sara Broaders and I discovered that child witnesses can also be misled by a more neutral question such as "What else was he wearing?" if, say, the interviewer produces a "hat" gesture (moving the hand as though to tip a hat). In our experiment, we interviewed 39 five- and six-year-olds over a 10- to 12-week period about a live music demonstration we had arranged for their classes. We asked them about events that happened during the demo as well as some that had not occurred, providing details in our interviews in both speech and gesture that might mislead the children. The result? Our suggestive gestures misinformed them just as powerfully as did our slanted verbal queries. —*S.G.-M.*

GETTY IMAGES

CORBIS

Students benefit when a teacher conveys different information in her gestures than she does in her speech. This strategy apparently gives kids more information about a topic or the ways to solve a problem.

wherein water is poured from one container to another). Thus, gesture seems to be a way of off-loading information from the mind, improving its ability to focus on other work or on other facets of a difficult problem. Gesturing while talking could, in principle, lighten the load when narrating anything complicated, for example, when telling an intricate story, describing how two people are related or explaining how gravity works. Using your hands can make the telling easier, allowing you to attend to other aspects of the conversation—such as a listener's facial expression or what you will say next.

In the classroom, gesture has additional uses. If teachers pay close attention to children's hand movements, they may be able to see the leading edge of a child's knowledge and thereby determine what the child is ready to learn next. Teachers can also tell what the child's misconceptions are and try to correct them. Teachers should encourage their students to gesture, not only to find out what they know but also to provide an engine for intellectual growth in the children.

In addition, teachers can incorporate gestures into their lessons. Our research reveals that kids especially benefit when a teacher suggests one correct strategy in words and another in gesture, offering a gesture mismatch of their own. For example, on the problem $7 + 2 + 4 = \_ + 4$, one teacher said, "You can solve this problem by making one side equal to the other side," an equalizer strategy, while at the same time gesturing an add-subtract strategy. That is, the teacher pointed at the 7, 2 and 4 on the left side of the equation in succession and then produced a take-away gesture near the 4 on the right (to suggest adding up the numbers on the left and subtracting the number on the right). Providing two strategies in different modalities seems to give the child more information about how to solve a problem. But teachers need to be careful not to inadvertently misdirect students with their gestures, because hand movements can mislead as well as inform [*see box on opposite page*]. Yet, in general, cultivating gesture in the classroom can smooth the path toward knowledge. M

(Further Reading)

- **Hand and Mind: What Gestures Reveal about Thought.** David McNeill. University of Chicago Press, 1992.
- **Gesture: Visible Action as Utterance.** Adam Kendon. Cambridge University Press, 2004.
- **Gesture and Thought.** David McNeill. University of Chicago Press, 2005.
- **Visible Embodiment: Gestures as Simulated Action.** A. B. Hostetter and M. W. Alibali in *Psychonomic Bulletin and Review,* Vol. 15, No. 3, pages 495–514; 2008.