Amanda Noroña

Gesture Facilitates Learning by Guiding Attention

Hand gestures naturally accompany speech. People of all ages and ethnicities use their hands when they talk (Kendon, 1997; Feyereisen & deLannoy, 1991); even congenitally blind individuals use gestures when they communicate (Iverson & Goldin-Meadow, 1998). Gesturing is especially common when the speaker intends to instruct the listener. For example, the frequency of children's gestures increases when they attempt more difficult explanations, such as explaining board game rules to an adult (Evans & Rubin, 1979). In the case of instruction, gesturing seems to benefit both the communicator and the recipient. Research has shown that, for the communicator, gesturing while explaining a novel task leads to greater success on the same task after explicit training (Ehrlich, Levine, & Goldin-Meadow, 2006). Gestures also clearly aid the recipient's understanding. In fact, one study found that recipients understood and learned better from gesture-only instructions than from speech-only instructions (Lozano & Tversky, 2006).

The effects of gesturing in the classroom, the most common forum for instruction, however, have only recently been investigated. In the last decade or so, researchers have begun to study the role of gesturing primarily in the fields of mathematics (Alibali, 1999; Cook, Mitchell, & Goldin-Meadow, 2008; Singer & Goldin-Meadow, 2005) and science (Lemke, 1999; Roth, 2000). However, much of this research has focused mainly on establishing the relationship between gesturing and learning, but not the mechanism through which this relationship is created. The present study investigates the function of gesturing in the learning process with the goal of augmenting classroom instruction.

Gestures indicate a learner's readiness

Research has found that spontaneously produced gestures are a window to a learner's mind (Goldin-Meadow, 1997). That is, when learners begin to assimilate new information, evidence can first be found in their gestures; children often express their knowledge of a new concept in their gestures even before they are able to articulate it (Alibali, 1999). Furthermore, studies have shown that children often indicate their level of implicit knowledge and a readiness to learn new concepts when the information they convey in speech does not match the information they convey in gesture. For example, Church and Goldin-Meadow (1986) found that children who gave discordant explanations for Piagetian conservation judgments (i.e., verbally attributed judgment to height discrepancy while gesturing the width discrepancy) were more receptive to training. This suggests that hand gestures can reveal knowledge of which a learner may not be explicitly aware. Gestures, therefore, can be important tools for educators to use to gauge a student's knowledge and receptivity to instruction.

Can we use gestures as a tool to create implicit knowledge or make implicit knowledge explicit?

Given that gestures indicate a student's implicit knowledge, can gestures create new knowledge? Many studies suggest that gestures play an important role in instructional communication; when teachers use gesture as they teach, children learn more (Valenzeno, Alibali, & Klatzky, 2003). This is the case even when students cannot understand the language the teacher speaks (Church, Ayman-Nolley, & Mahootian, 2004)! Interestingly, Singer and Goldin-Meadow (2005) found that children can also learn when their teacher's gestures and speech differ. A math teacher, for example, can verbalize one strategy for solving a math problem and gesture another. In this case, gesture offers learners a second message, which therefore presents students a choice of which message to assimilate. Additionally, Cook and Goldin-Meadow (2006) found that children who were instructed with gesture were more likely to subsequently produce their own gestures and were also more successful on a subsequent posttest. Thus, they advocate that teachers' gestures facilitate learning because they encourage learners to produce gestures of their own, which, in turn, leads to learning. These studies, however, address situations in which gestures are mandatory only for the instructor.

How is learning affected when learners are required to gesture? Two recent studies propose that forcing students to gesture brings out implicit knowledge, makes students more receptive to learning (Broaders, Cook, Mitchell, & Goldin-Meadow, 2007) and helps students retain the knowledge longer (Cook, Mitchell, & Goldin-Meadow, 2008). Broader and colleagues (2007) told children to gesture while explaining their solutions to novel math problems. Interestingly, children who incorrectly solved the math problems often added new and correct problem-solving strategies to their explanations, expressed only in gesture. In other words, these children did not give a correct explanation in speech but gestured a correct strategy. They were also more successful on the math problems after they were given instruction on the correct strategies. In addition, Cook, Mitchell, & Goldin-Meadow (2008) found that children who were required to gesture scored significantly better on a delayed posttest administered four weeks after an instruction phase. This effect was significant even for children who were required to gesture without any accompanying speech. Therefore, gestures not only bring out implicit knowledge but also help newly acquired knowledge last.

How does gesture facilitate learning?

Thus far we have established that spontaneous gestures can predict whether a child is ready to learn a task, that teachers' gestures encourage learning, and that learners' gestures make implicit knowledge explicit. The question that remains is: How? What is the mechanism underlying gesturing that creates these learning gains? Current research illuminates three possible explanations for this robust relationship between gesture and learning.

First, several studies suggest that gesturing facilitates learning by reducing cognitive load. In this theory, gesturing serves as an alternative, less demanding representation of new information; learners can then allocate more cognitive resources to encoding the new knowledge. In one study, participants were asked to remember a list of words while explaining their solution to a novel math problem. Subjects who were instructed to gesture during the explanation remembered more words than subjects who were told to keep their hands still. (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001). Goldin-Meadow and colleagues suggest that subjects who gestured were able to dedicate more cognitive resources to the memory task than subjects who did not gesture because of the less demanding quality of gesture. Along these lines, Wagner, Nusbaum, and Goldin-Meadow (2004) investigated the type of mental representation that underlies gestures. Although many past studies suggested a visuospatial basis for gesturing, they found that gesturing has the same impact on visuospatial and verbal working memory; that is, allowing subjects to gesture facilitated their recall of both visuospatial and verbal items. Although research suggests that gesturing reduces cognitive load, the type of cognitive load gesture exerts on the brain, while diminished, has not yet been determined.

Other researchers propose that gesturing facilitates learning because involving general movement in the learning process helps encode information. Studies have found that involving motor movements produces stronger and more robust memory traces. Indeed, actors remember the lines they produce while moving better than the lines they produce while motionless (Noice & Noice, 1999) and children can remember stories better when they enact them with objects than when they read them twice (Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004). Ravizza (2003) investigated the idea that non-representative movements (as opposed to semantically-based gestures) can enhance memory for new information. She found that foot tapping increased participants' word retrieval, which suggests that any form of body movement aids in memory retrieval.

The third theory is that gestures facilitate comprehension and learning by directing learners' attention to relevant parts of the external environment. Gestures allow students to link mental representations of their teachers' words with informative environmental stimuli. Valenzeno and colleagues (2003) state that "pointing and tracing gestures "ground" teachers' speech by linking abstract, verbal utterances to the concrete, physical environment." Gestures, thus, serve as a visual support for speech and help clarify the teacher's instructional message. In addition, Grant and Spivey (2003) found that guiding a learner's attention can guide his thought. They presented participants with a notoriously tricky word problem and a diagram on which to draw the solution. When a particularly salient aspect of the diagram was highlighted via computer animation, the participants tended to solve the problem correctly.

We believe that gestures serve a similar function as this computerized highlight: they guide a learner's attention. However, this relationship has yet to be systematically manipulated. While it's clear that gesturing and directing attention both independently facilitate learning, there is no established relationship between the two variables, such that gesturing facilitates learning solely or partly because it directs attention. Therefore the present study investigates this third theory, which advocates that gestures facilitate learning by guiding learners' attention to relevant parts of the external environment. We hypothesize that the association between gesturing and learning is mediated by attention direction. In order to investigate this premise, we instructed young elementary school students on a relatively tricky math concept and manipulated the method of instruction. We instructed the students using (1) speech only, (2) speech and a computer-animated highlight, or (3) speech, a computer-animated highlight, and hand gesturing. We predict that, because gesture's main purpose is to direct attention, subjects instructed with speech and a computer-animated highlight will achieve the same level of concept learning and retention as subjects instructed with speech, a computer-animated highlight, and hand gesturing.

References

Alibali, M. W. (1999). How children change their minds: Strategy change can be gradual or abrupt. *Developmental Psychology*, 35(1), 127-145.

Broaders, S. C., Cook, S. W., Mitchell, Z., & Goldin-Meadow, S. (2007). Making children gesture reveals implicit knowledge and leads to learning. *Journal of Experimental Psychology*, 136(4), 539-550.

Church, R. B., Ayman-Nolley, S., Mahootian, S. (2004). The role of gesture in bilingual education: Does gesture enhance learning?. *International Journal of Bilingual Education and Bilingualism*, 7(4), 303-319.

Church, R. B., Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of transitional knowledge. *Cognition*, 23(1), 43-71.

Cook, S. W., Goldin-Meadow, S. (2006). The Role of Gesture in Learning: Do Children Use Their Hands to Change Their Minds?. *Journal of Cognition and Development*, 7(2), 211-232.

Cook, S. W., Mitchell, Z., Goldin-Meadow, S. (2008). Gesturing Makes Learning Last. *Cognition*, 106, 1047-1058.

Ehrlich, S. B., Levine, S. C., & Goldin-Meadow, S. (2006). The importance of gesture in children's spatial reasoning. *Developmental Psychology*, 42(6), 1259-1268.

Evans, M. A., & Rubin, K. H. (1979). Hand gestures as a communicative mode in school-aged children. *The Journal of Genetic Psychology, 135,*189–196.

Feyereisen, P., deLannoy, J. D. (1991). *Gesture and speech*. New York: Cambridge University Press.

Glenberg, A. M., Gutierrez, T., Levin, J. R., Japuntich, S., & Kaschak, M. P. (2004). Activity and imagined activity can enhance young children's reading comprehension. *Journal of Educational Psychology*, 96(3), 424-436.

Goldin-Meadow, S., Cook, S. W., Mitchell, Z. A. (2009). Gesturing Gives Children New Ideas About Math. *Psychological Science*, 20(3), 267-272.

Goldin-Meadow, S., Nusbaum, H., Kelly, S. D., Wagner, S. (2001). Explaining math: Gesturing lightens the load. *Psychological Science*, 12(6), 516-522.

Goldin-Meadow, S., Wagner, S. M. (2005). How our hands help us learn. *Trends in Cognitive Sciences*, 9(5), 234-241.

Grant, E. R., Spivey, M. J. (2003). Eye movements and problem solving: Guiding attention guides thought. *Psychological Science*, 14(5), 462-466.

Iverson, J. M., & Goldin-Meadow, S. (1998). Why people gesture when they speak. *Nature*, 396(6708), 228.

Kendon, A. (1997). Gesture. *Annual Review of Anthropology, 26,*109–128.

Lemke, J. L. (1999). Typological and topological meaning in diagnostic discourse. *Discourse Processes, 27,*173–185.

Lozano, S. C., & Tversky, B. (2006). Communicative gestures facilitate problem solving for both communicators and recipients. *Journal of Memory and Language*, 55(1), 46-63.

Noice, H., & Noice, T. (1999). Long-term retention of theatrical roles. *Memory*, 7(3), 357-382.

Ping, R. M., Goldin-Meadow, S. (2008). Hands in the air: Using ungrounded iconic gestures to teach children conservation of quantity. *Developmental Psychology*, 44(5), 1277-1287.

Roth, W.-M. (2000). From gesture to scientific language. *Journal of Pragmatics, 32,* 1683–1714.

Singer, M. A., Goldin-Meadow, S. (2005). Children Learn When Their Teacher's Gestures and Speech Differ. *Psychological Science*, 16(2), 85-89.

Stevanoni, E., & Salmon, K. (2005). Giving memory a hand: Instructing children to gesture enhances their event recall. *Journal of Nonverbal Behavior*, 29(4), 217–233.

Valenzeno, L., Alibali, M. W., & Klatzky, R. (2003). Teachers' gestures facilitate students' learning: A lesson in symmetry. *Contemporary Educational Psychology*, 28(2), 187–204.

Wagner, S. M., Nusbaum, H., & Goldin-Meadow, S. (2004). Probing the mental representation of gesture: Is handwaving spatial?. *Journal of Memory and Language*, 50(4), 395–407.

Wolff-Michael, R. (2001). Gestures: Their Role in Teaching and Learning. *Review of Educational Research*, 71(3), 365-392.