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Children Learn from Gestures Not Grounded in the Here-and-Now

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Abstract

Children learn better when their instructions include both gesture and speech than when instructions consist of speech alone (Perry, Berch & Singleton, 1995; Valenzeno, Alibali, & Klatzky, 2003; Church, Ayman-Nolley & Mahootian, 2004). The present research investigates whether this effect is due solely to gesture's ability to ground words in the world. We found that children improved more on Piagetian conservation tasks when their instruction included both iconic gestures and speech than when instruction consisted of speech alone. This was true even when the objects to which the gestures referred were not visible. These findings suggest that, although gesture's ability to direct attention to objects and actions in the visible world may be important in learning contexts, gesture is capable of doing more for learners than simply grounding arbitrary, symbolic language in the physical, observable world.

Keywords: gesture, instruction, development, embodiment, education, psychology

Introduction

Although we may not be explicitly aware of the gestures we produce or the gestures that our communicative partners produce, gesture is a pervasive part of our communicative interactions with other people. Gesture is out there, as "underground information [that] is integrated with the information conveyed in speech by both speaker and listener" (Goldin-Meadow, 2003, p. 103). One type of communicative situation in which gesture appears to be particularly important is the adult-child learning interaction. Children's gestures communicate information about what they know and how they view a problem (e.g., Church & Goldin-Meadow, 1986; Perry, Church & Goldin-Meadow, 1988; Goldin-Meadow, Alibali & Church, 1993; Alibali & Goldin-Meadow, 1993), and teachers' gestures help children learn about a multitude of tasks (e.g., Perry, Berch & Singleton, 1995; Valenzeno, Alibali & Klatzky, 2003; Church, Ayman-Nolley & Mahootian, 2004).

Teachers use gesture in children's everyday learning environments across a variety of domains and age groups. When teachers teach first graders about mathematics, they use gesture more than other nonverbal materials, such as counting blocks and other instructional aids (Flevares & Perry, 2001). High school science teachers appear to "layer" explanations of physics problems, with visible objects as one layer, explanation-rich speech as a second layer, and a third layer consisting of meaningful iconic gestures that ground the language in the world by tying the speech to the objects to which it refers (Roth & Welzel, 2001).

In addition, children can understand the information their teachers put forth in gesture. Preschool-aged children can understand a message that is divided between gesture and speech better than they can understand either speech or gesture alone (Kelly, 2001). Seven- and eight-year-old children who watched video tapes of other children participating in conservation tasks were able to glean information from the gestures those children produced, even when the gestures included information that was not included in the children's speech (Kelly & Church, 1997; see also Singer & Goldin-Meadow, 2005).

Children not only pay attention to information conveyed in gesture, but they also learn from it. When children were presented with instruction in math equivalence that had both speech and matching pointing gestures, they were more likely to learn than children who received instruction that had speech only (Perry et al., 1995). In addition, preschoolers who were instructed in symmetry learned more when their instruction included both speech and matching pointing and tracing gestures than when it included speech alone (Valenzeno et al., 2003). When Church, Ayman-Nolley and Mahootian (2004) presented children with training on Piagetian conservation tasks, the children learned better when the training included both speech and iconic gestures than speech alone.

Although different kinds of gestures were used in each of these three studies, all of the gestures directly indexed the objects or problems being considered. In contexts such as these, gesture may serve as a sort of bridge between arbitrary, symbolic speech and the highly perceptual, experienced physical world. Gesture can be seen as living between these two worlds, as it has iconic properties that are symbolic in that they are not literally the things they indicate or stand for, but they are also highly perceptual and are produced in real space. It has been proposed that "gestures 'ground' teachers' speech by linking abstract, verbal utterances to the concrete, physical environment" (Valenzeno et al., 2003 p. 187). This may be true, but it is also possible that gestures can help children learn even when they stand on their own. That is, when the "concrete, physical environment" to which gestures refer is not immediately accessible to children, will gesture still help them learn? Alternatively, is this hypothesized bridging function the only way that viewing gesture can help children learn?

The present research investigates these possibilities by examining whether children can learn from gesture even when the objects to which the gestures refer are not visible. In this experiment, children participated in a pretest-training-posttest paradigm. They received instruction either with speech only or with speech plus iconic gesture, and with or without the objects to which the training referred. In the *objects present* conditions, we expect that children will improve more with training that includes both speech and gesture than training that includes speech only, replicating Church et al.'s (2004) finding that gesture helps children learn about conservation. If gesture confers the same benefit in the *objects absent* conditions, we will have evidence that gesture can stand on its own without props in teaching children a new concept.

Method

Participants were 43 kindergarten students from Chicago area public and private schools (average age 5.5 years). There were 20 (45%) female and 23 (55%) male students. Children participated individually in the experiment during the normal school day. The experiment consisted of a pretest, a training session, and a posttest. Children received a small prize after participating in the experiment.

The pretest consisted of eight conservation tasks, two each of liquid (volume), number, length, and mass. At the beginning of each pretest trial, the child was presented with two identical stimuli (e.g., two identical glasses with the same amount of water inside) and was asked whether the two were equal in amount. Once the child agreed that the two were equal, one of the stimuli was transformed (e.g., water in a tall, thin glass was poured into a short wide dish), and the child was again asked whether the two were equal in amount. Regardless of the answer, the child was asked for a reason. The stimulus was transformed back into its original state, and the child was once again asked whether the two were equal.

Each child was trained on liquid and number conservation by a different experimenter from the one who administered the pretest. The training session consisted of three liquid training trials and three number training trials. Liquid and number were presented in counterbalanced blocks, and the three training trials were randomized within these blocks. For each training trial, the experimenter first gave instruction and then allowed the child to do a problem with feedback. For example, in a liquid training trial, the experimenter put up two identical glasses with the same amount of water. She said, "I think these two have the same amount of water." Then she poured the liquid from one of the glasses into a different shaped container and said, "I think these two glasses have the same amount of water in them." In the *objects present* conditions, the objects stayed on the table, within the child's view, as the experimenter said the training statement: "One of the glasses is taller and the other one is shorter, but the shorter glass is wider and the taller glass is skinnier. So it makes up for it." This statement demonstrates the *compensation strategy*, the idea that there is more than one dimension on which the glasses can be measured and that those dimensions compensate for one another. In the *objects absent* conditions, the experimenter takes the glasses off the table before saying the training statement. In the *gesture + speech* conditions, appropriate iconic gestures were performed near the glasses (in the *objects present* condition) or in the air near where the glasses had been (in the *objects absent* condition) along with the training statement. For example, the experimenter indicated the height of the glasses with palms flat and perpendicular to the table and then indicated the width of the glasses with appropriately sized C-shapes at the height of the glass. The gestures in this case demonstrated *both* the height and the width of the glasses at the same time, a key component of understanding the compensation strategy. In the *speech only* conditions, the experimenter produced the same training statement (using precisely the same words and intonation pattern) but produced no gesture. The stimuli were then returned to their initial state and the experimenter said, "I think these two glasses have the same amount of water in them."

The second half of each training trial consisted of the child solving one problem and getting feedback. For example, the experimenter put two identical glasses with equal amounts of water up on the table and asked the child whether the two had the same amount of water. One of the stimuli was then transformed and the child was asked if the two had the same amount of water. In the *objects absent* conditions, the glasses were taken off the table, out of view of the child. In the *objects present* conditions, the glasses were left on the table. The child was asked the reason for his or her judgment. If the child gave a correct answer, the experimenter said, "I think you're right. I think they do have the same amount of water" and then gave the training statement again. If the child gave an incorrect answer, the experimenter said, "Actually, I think they have the same amount of water" and then gave the training statement. In the *gesture + speech* conditions, the training statement was accompanied by appropriate iconic gestures, and in the *speech only* conditions, the training statement was the same but there were no gestures presented. The stimuli were then returned to their initial state and the child was asked whether the two glasses had the same amount of water. Training trials followed a similar protocol for the number training.

The posttest was administered by the same experimenter who administered the pretest. No feedback was given.

The child's equality judgment (same or different) for each question on the pretest, training, and posttest was recorded, along with the strategies he or she expressed in speech and gesture. The strategies expressed in both speech and gesture were coded using criteria developed and used in previous studies (e.g., Church & Goldin-Meadow, 1986). Speech was coded without watching the gesture, and gesture was coded on a second pass without listening to the speech.

In order to be coded as having answered a problem correctly, the child had to produce a "same" judgment after the transformation and give a correct strategy as justification. The child's score is the number of correct answers on the posttest minus the number of correct answers on the pretest. Since there are many correct strategies children can use in these tasks, we also calculated the number of correct strategies added from pretest to posttest as a more sensitive measure of learning (cf. Church & Goldin-Meadow, 1986).

Results

Pretest scores did not vary across the four conditions. Children in each condition started out in the same knowledge state, without any significant differences among them. All data were analyzed as proportions and therefore underwent arcsine transformations before analysis. Means are presented as proportion correct unless otherwise indicated.

We found that children given instruction in both gesture and speech (regardless of presence or absence of objects) improved their proportion of correct answers by .30 (SD=.36), whereas children given instruction in speech only (regardless of presence or absence of objects) improved their proportion of correct answers by only .11 (SD=.21), $F(1, 39) = 4.24$, $p < .05$.

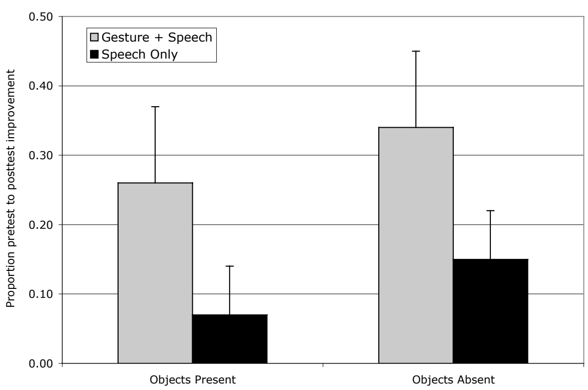

Figure 1: Pretest to posttest improvement in correct answers

Moreover, children who received gesture and speech instruction added more correct strategies from pretest to posttest than children who received instruction in speech only (gesture + speech = 1.50, SD=1.60, vs. speech only = .38, SD=.80), $F(1, 39) = 8.33$, $p < .01$. Importantly, there were no main effects of objects being present or absent and there were no interactions for improvement in scores (Figure 1) or in the number of correct strategies added from pretest to posttest (Figure 2). Gesture appears to be helping children learn about conservation, whether or not the objects to which the gestures and speech refer are visible to the child.

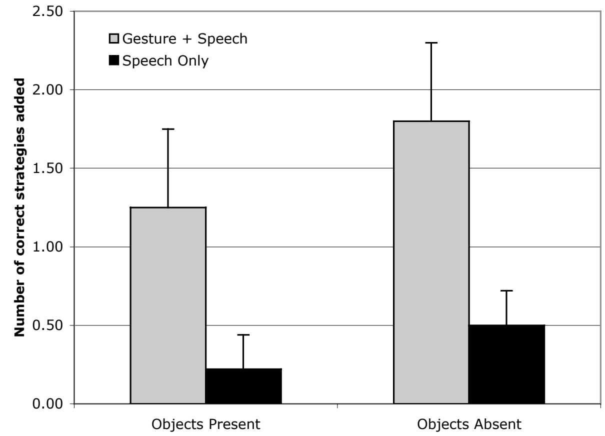

Figure 2: Number of correct strategies added from pretest to posttest

Discussion

The present research reveals that gesture can help children learn even when the gestures are not grounded in the immediately visible physical world. We found that children improved more from pretest to posttest when their instruction included both gesture and speech than when it included speech only. This was true whether or not the objects to which the gestures referred were visible. Children given gesture and speech instruction also added more correct strategies from pretest to posttest than did children given instruction in speech only. These findings suggest that gesture may help children understand a problem more deeply, even when the objects to which the gestures refer are not present. In these instances, gesture appears capable of doing more than simply "grounding" language in the world, or connecting the spoken language with visible objects.

However, it is still unclear what exactly gesture is doing during the learning process. Recall that there were no significant differences between the *objects absent* conditions and the *objects present* conditions. Is gesture working in the same way regardless of whether the objects are visible? If so, then how is it working? It could be that the gestures highlight the important aspects of the stimuli and help the child create a representation of the problem that includes the symbiotic relationship between gesture, speech, and the visible environment, as seems to be true for learning interactions among adults (Goodwin, 2003). For example, the gestures and speech in the liquid training first highlighted a height comparison between the objects and then highlighted a circumference comparison (while maintaining the difference in height). Thus, the gestures could be pointing out the important comparisons to the child and could be working because they were performed in relation to the visible objects.

But if this is the case, what then is gesture doing when the objects are not present? It could be working in the same way, albeit in relation to a mental image of the objects. Or, the gestures could be working more abstractly, helping the child grasp the compensation strategy at a level that is not tied to the particular objects. Adults have been shown to build embodied simulations of nonvisible entities (as evidenced in their gestures) in situations ranging from everyday conversation (Parrill & Sweetser, 2004) to math lectures (Núñez, 2004) to talking about time (Núñez & Sweetser, 2006). It is unclear when children are themselves able to construct embodied simulations of this sort. However, our data make it clear that children are able to take advantage of simulations that have been constructed by others. The open question is how.

In sum, these observations expand previous results demonstrating that gesture helps children learn in situations where its role is highly referential. We have shown that gestures can help children learn even when the objects to which they refer are not directly visible. Gesture is therefore capable of playing more than merely a grounding referential role, not only in conversations among adults, but also in teaching situations involving young children. In future research, our plan is to explore more explicitly the *mechanism(s)* by which gesture helps children learn in these contexts.

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