Title
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Teachers Can Intentionally Alter their Instructional Gestures

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Abstract

Because gestures can ground abstract ideas in the physical world and make connections between ideas, they play a potentially important role in the classroom. This study examined whether teachers can intentionally alter their gesture production. Six teachers taught a brief mathematics lesson three times, once without any special instructions, once attempting to use gestures to link ideas, and once attempting to inhibit all gestures. All 6 teachers were able both to increase and inhibit their gesture production when asked to do so. These results suggest that teachers can alter their gesture production. This is promising evidence that interventions that require teachers to alter their gestures are feasible.

Introduction

Teachers often face the challenging task of helping their students see connections between different ideas, events, or lessons. For example, a science teacher may wish to demonstrate the similarities between the organs inside the pig her students are dissecting and the organs inside their own bodies. A reading teacher may wish to demonstrate the relations between the events in the story the students are reading and events in the real world. A math teacher may wish to illustrate the connections between the equations the students are writing and the physical situation the equations model.

Explaining connections between ideas is a complex process, one that is successful only if students can ground their understanding of one event or idea in their understanding of the other. One tool that teachers may use to help students see connections and ground their understanding of abstract ideas in the physical world is representational gestures. Representational gestures accomplish this grounding by directing attention to the referents for speech or by physically realizing those referents. Pointing gestures can explicitly direct students' attention to a physically present referent. Iconic gestures can use the shape or motion of the hands to mime a key aspect of the referent.

The imagistic information conveyed by gestures may benefit learning. Dual Coding Theory (Paivio, 1986) suggests that memory is enhanced when imagistic information is incorporated during encoding. Indeed, there is growing evidence that students benefit from their teachers' gestures. Research shows that children can detect conceptual information that others express in gestures (Kelly & Church, 1998). Furthermore, the information that teachers express in gestures appears to influence learning. Many studies have shown improved performance on a posttest after a lesson that contained gestures compared to a lesson that did not contain gestures (Church, Ayman-Nolley, & Maldonado, 2005; Perry, Birch, & Singleton, 1995; Valenzeno, Alibali, & Klatzky, 2003). For example, Church, Ayman-Nolley, and Maldonado (2005) found that 4th grade students who witnessed a lesson about equations that contained both speech and gesture solved three times more equations correctly on a posttest than students who witnessed a lesson that did not contain gestures.

Gestures appear to be a helpful classroom tool, and indeed, teachers spontaneously use gestures in their lessons. Flevares and Perry (2001) found that first-grade teachers used 5 to 7 "nonspoken representations" per minute in lessons about place value, and most involved gestures. Alibali and Nathan (2005) describe the gestures of one teacher giving a math lesson about how to compute the area of a rectangle. The teacher used gesture to trace the length of the rectangle while

referring to the letter *l* in the equation $A = lw$. He then mentioned the width of the rectangle while tracing the short side of the rectangle. Such gestures clearly link the words and symbols being spoken and written to more tangible objects in the student's environment (e.g., aspects of the pictured rectangle).

Although it appears that at least some teachers spontaneously use gestures to supplement their lessons in effective ways, it is not clear if all teachers understand the importance of gestures and use them effectively. To fully harness the potential of gestures in the classroom, it may be necessary to provide teachers with explicit instructions regarding the use of gestures to supplement and ground their speech. Such an intervention assumes, however, that speakers can control and change their gestures when asked to do so. This assumption may or may not have merit.

Many of the gestures speakers produce seem to be unintentional. Speakers often don't remember gesturing, and they have a difficult time accurately describing their gestures after the fact. This suggests that speakers may not consciously plan or alter their gestures; however, there is some evidence that speakers' gestures are influenced implicitly by their own communicative intent as well as by the knowledge and physical position of their audience.

McNeill and Duncan (2000) have shown that gestures often express information that is not encoded explicitly in speech. For example, due to the linguistic structure of their language, it is somewhat tedious for Spanish speakers to encode manner in speech. They often omit manner information from their speech (e.g., "he went down the hill"), but often include such information in gesture (e.g., making a repetitive circular motion to represent rolling). This suggests that gestures supplement speech in order to fully convey ideas that are difficult to encode linguistically.

Using a more experimental approach, Melinger and Levelt (2004) found that when speakers are given a specific communicative goal that includes conveying multiple pieces of information, many speakers convey some of the key information only in their gestures and not in their speech. Melinger and Levelt argue that such gestures are intended to communicate because they contain information that is part of the speaker's communicative goal.

In addition to conveying necessary information in their gestures, speakers also alter the form of their gestures according to their audience's knowledge about the material being spoken about. Gerwing and Bavelas (2004) have shown that gestures are less likely to convey specific information when the speaker and listener share common ground about the gestures' referents. Alibali and Nathan (in press) found that a teacher altered her gestures in response to students' questions and when problems were more complex. Thus, speakers appear to alter their gestures depending on the communicative context.

Finally, there is also some evidence that gestures are planned and executed so that they will make sense based on the observation angle of the audience. Özyürek (2002) demonstrated that speakers perform the same gesture differently depending on the location of the neutral space between speaker and listener.

All of this evidence (Alibali & Nathan, in press; Gerwing & Bavelas, 2004; McNeill & Duncan, 2000; Melinger & Levelt, 2004; Özyürek, 2002) suggests that speakers implicitly plan their gestures so that they will be effective given the communicative situation. The purpose of the present study was to determine whether speakers (specifically teachers) can also intentionally change their gestures when they have an explicit goal to do so. Teachers were asked to give a math lesson three times. After giving the lesson the first time, the teachers were given a brief tutorial about the effectiveness of linking important ideas in their gestures. They were then asked to give the lesson a second time, making an effort to incorporate as many gestures into their lesson as possible. Finally, they were asked to give the lesson a third time, this time attempting to refrain from gesturing as much as possible.

We hypothesized that if teachers are able to bring their gestures under conscious control and learn how to use them effectively after a brief tutorial, then teachers will produce more gestures after receiving instruction about the importance of doing so. Furthermore, if gestures can be brought under explicit conscious control, then teachers may also be able to inhibit their gestures when asked to do so. If teachers can indeed intentionally alter their gestures, they may be able to learn how to use gestures effectively in instruction.

Method

Participants

Six teachers (4 female, 2 male) volunteered to participate. Each teacher had at least one year of experience teaching math at the middle school level, and each was taking advanced classes in the Educational Psychology or Curriculum and Instruction department at the University of Wisconsin-Madison. Teachers were recruited via word of mouth and were compensated $25.00 for their participation.

Materials

A pan balance problem that depicted two pans resting on a triangular fulcrum was taken from Greenes and Findell (1998). Two spheres were shown on the left pan and one sphere and two cylinders were shown on the right pan. The balance holding the two pans was resting on the horizontal plane, thus representing the weight of the two pans in perfect balance. See Figure 1.

This pan balance problem was reproduced on a 3 foot x 5 foot poster. The poster was laminated and taped to a whiteboard. The teachers used dry erase markers to write on the board surrounding the poster during their lesson. The pan balance problem was also reproduced on a sheet of paper for the teachers to use in planning their lesson.

The experimenter used a different pan balance problem to explain the task to each teacher. This problem was drawn on

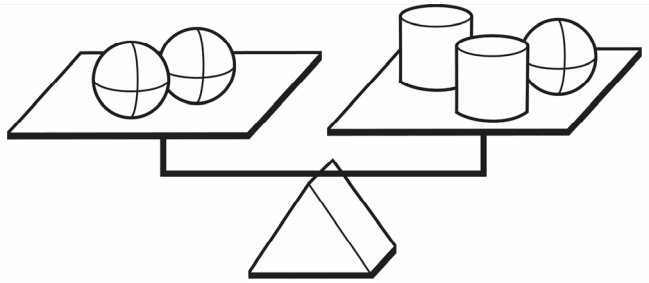

Figure 1: The pan balance used by the teachers in their lesson. Teachers explained how to write an equation based on the picture (e.g., 2s = 2c + s) and then how to simplify the equation to represent the weight of one sphere (e.g., s = 2c).

a piece of paper and was accompanied by a an equation that correctly represented it. The teacher's lessons were video-taped using a color Sony DCR-VX2000 camera attached to a tripod. To assure a quality audio recording as well, a Samson T32 Wireless microphone was attached to each participant's clothing.

Procedure

Teachers arrived individually to a quiet conference room where an experimenter and an audio-video specialist were present. The teachers were told that the experiment addressed whether or not teachers can intentionally alter the gestures they use while they are teaching.

After signing the consent form, each teacher received materials and instructions for the brief math lesson they were going to teach. The teachers were told to imagine that they were in a classroom full of students who had little or no knowledge of algebra (roughly 6th grade students). Their task was to explain to their hypothetical students how to turn a drawing of a physical system into an algebraic equation (see Figure 1). They were instructed to demonstrate how to write the equation using variables to represent the shapes pictured, and then simplify the equation to represent the weight of one sphere in terms of the other shapes. The experimenter briefly highlighted some important connections that should be mentioned in the lesson, such as the link between the fulcrum in the pan balance and the equal sign in the equation. The teachers were also told that they should use a strictly lecture format for their lesson; although the experimenter would be listening attentively during the lesson, the teachers should not ask her questions or ask her to work through the problem with them. Otherwise, each teacher was free to design the lesson however he or she wanted. Teachers were given up to 10 minutes to prepare their lessons, but none required the full amount of time.

Once the teacher was ready to begin the lesson, the audio-visual specialist attached a small microphone to his or her clothing and positioned the camera to capture a waist-up view of the teacher's lesson. When ready, the teacher gave the lesson, taking as much time as needed.

Following this baseline lesson, the experimenter gave the teacher a brief tutorial about the effectiveness of using hand gestures to link ideas. The experimenter briefly described the concept of a linking gesture and gave the teachers several examples of how to incorporate linking gestures into their lessons. For example, when talking about the similarity between the fulcrum in the pan balance and the equal sign in the equation they were writing, the teachers could point to both the fulcrum and the equal sign simultaneously. Similarly, the teachers could link each shape in the picture to its corresponding variable by pointing first to the shape and then to the symbol in the equation. Once the teacher confirmed that he or she understood the concept of a linking gesture, the board was erased and the teacher gave the lesson a second time. In this *gesture* condition, however, they were asked to try to reinforce their lessons with hand gestures.

Each teacher was then asked to give the same lesson a third time in an *inhibit* condition. In this condition, the teachers were asked to refrain from gesturing during the lesson. The teachers were allowed to use one hand to write the symbols and equation on the whiteboard, but they were asked to keep their hands as still as possible otherwise. The experimenter suggested that the teachers hold onto a stack of papers, put their hands in their pockets, or cross their arms to remind themselves not to gesture. The experimenter erased the board and the teacher gave the lesson a third time.

Following the three lessons, the teachers were debriefed and given additional information about the importance of gestures in teaching. They were thanked and compensated for their participation.

Coding

Each teacher's three lessons were transcribed verbatim. Two coders then used the audio-visual program Transana (Fassnacht & Woods, 2005) to identify and code the gestures and linking episodes produced by the teachers.

Each representational gesture was identified from the stream of manual activity and classified into one of three categories: iconic, point, or writing. An iconic gesture was any gesture that took the shape of the information being conveyed. For example, if a teacher made an O-shape by curling the fingers of one hand while saying, "we have one sphere", this gesture was coded as an iconic gesture. A point gesture was any gesture that directed the audience's attention toward a specific feature of the picture or equation, usually by touching the relevant feature with the extended index finger of one hand. Pointing gestures were considered as separate gestures if they were temporally separated from one another. For example, if a teacher pointed to a sphere and then pointed to an "s" in the equation, this was counted as two pointing gestures. In contrast, if a teacher pointed to the sphere with her right hand while simultaneously pointing to the "s" in the equation with her left hand, the action was counted as one pointing gesture. Although

Table 1. Examples of Linking Episodes Made in Speech and Gesture

Speech	Gesture	Type of Gesture	Type of Link	Mode of Link
"This thing is just like a see saw you might see on the playground."	Right forearm rests on top of left fist and rocks back and forth, alternating the height of the wrist and elbow.	Iconic	Pan to Other	Speech Link
"We write an S for each sphere we see on the pans."	Right hand writes s + s on the board.	Writing	Pan to Equation	Speech Link
"And then we can say that the halves of the pan are equal because they're balanced"	Left hand points to left side of pan, then to right side of pan, then back to the left side.	Point	Pan to Pan	Both Gesture and Speech Link
"Two S's…"	Right hand points to the spheres on the left pan.	Point	Pan to Equation	Combined Gesture and Speech Link
"And over here we have 1s plus 2c"	Left hand points to right side of pan while right hand writes 1s + 2c on the board.	Point Writing	Pan to Equation	Gesture Link

writing is not usually considered a gesture, we counted it as a gesture in this context because the teachers often used writing to convey or link information (particularly in the inhibit condition). Writing gestures were recorded in bouts; as long as the teacher was writing continuously on the board, the writing was counted as one writing gesture. Whenever the teacher paused writing for more than one second, a new writing gesture was counted if she began to write again. Most writing gestures occurred with speech. For example writing *2s* on the board while saying "We can write *2s* to represent the two spheres" was counted as one writing gesture. Writing gestures in all three conditions were constrained to writing aspects of the equation.

The coders also identified *linking episodes* in the teachers' speech and gestures (see Alibali & Nathan, in press). A linking episode was defined as an instance where the teacher made a connection between two events or objects. Links could be made between the two sides of the pan balance, between the two sides of the equation, between the pan balance and the equation, between the pan balance and other real-world objects (e.g., a see saw on the playground), or between the equation and other objects. Furthermore, each linking episode could be made entirely in speech, entirely in gesture, in both speech and gesture (i.e., the entire link made in each modality), or in a combination of gesture and speech (i.e., part of the link expressed in speech and part in gesture). For example, a teacher who said "two S's" while pointing to the two balls on one of the pans linked the balls with the variable representing the balls through a combination of speech and gesture. The link was not made entirely in speech or entirely in gesture; rather it was the combination of gesture and speech that linked these ideas. See Table 1 for examples of each type of linking episode.

Reliability

The two coders both coded a randomly selected three-minute-segment taken from each of the conditions given by one teacher. Agreement for identifying individual gestures was 93%. Agreement for classifying each gesture as pointing, iconic, or writing was 89% ($N = 89$). The coders' agreement for identifying linking episodes was 85%, with 89% agreement for classifying each episode as involving speech, gesture, or both ($N = 36$).

Results

Analysis of Gestures

To determine whether teachers were able to alter their gesture production in accordance with the explicit instructions they received, we conducted a 3 (condition: baseline, gesture, inhibit) x 3 (type: point, iconic, writing) repeated measures ANOVA. A main effect of condition emerged, $F(2, 20) = 107.60$, $p < .001$. Teachers produced more gestures following explicit instructions about the importance of including gestures in their lessons ($M = 70.00$, $SD = 10.77$) than they produced initially without any instructions regarding gestures ($M = 51.17$, $SD = 7.73$). They produced the fewest number of gestures after being told to inhibit their gestures ($M = 13.83$, $SD = 2.32$). There was also a main effect of type of gesture, $F(2, 20) = 28.36$, $p < .001$. Points ($M = 25.17$, $SD = 2.83$) were more prevalent in the teachers' lessons than iconic ($M = 6.83$, $SD = 5.34$) or writing ($M = 13.00$, $SD = 3.19$) gestures. Finally, an interaction between gesture type and condition emerged, $F(4, 20) = 39.73$, $p < .001$. The tendency to produce more gestures in the gesture condition than in the baseline condition was true for pointing gestures, but not for iconic or writing gestures. The tendency to produce fewer gestures in the inhibit condition than in the baseline condition was true for pointing and iconic gestures, but not for writing gestures. See Figure 2.

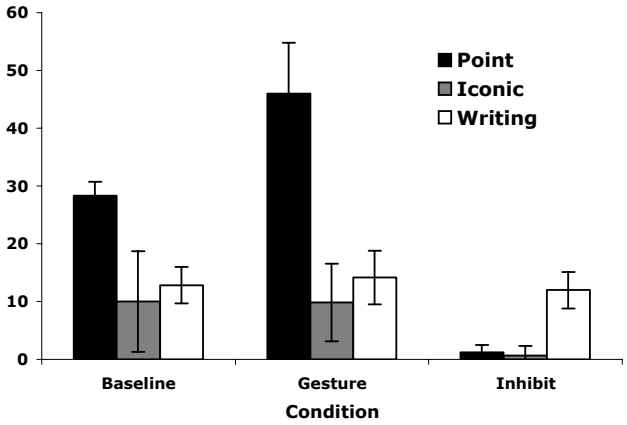

Figure 2. The mean number of gestures used by teachers in each of the three conditions. Error bars were calculated using MS_{error} as the measure of population variance.

Analysis of Linking Episodes

We were also interested in whether or not teachers could use gestures specifically to link information after being instructed to do so. We compared linking episodes that contained gestures (coded as gesture links and combined gesture speech links, see Table 1) and linking episodes that did not contain gestures (speech links) in the three experimental conditions. The 3 (condition: baseline, gesture, inhibit) x 2 (type of link: gesture, speech) repeated measures ANOVA revealed a main effect of condition, $F(2, 10) = 7.73$, $p = .009$. Speakers produced fewer linking episodes after receiving instructions to inhibit their gestures ($M = 19.67$, $SD = 8.69$) than after receiving instructions to enhance their gestures ($M = 39.00$, $SD = 16.38$), $t(5) = 3.36$, $p = .02$, or after receiving no instructions regarding gestures ($M = 29.00$, $SD = 9.30$), $t(5) = 4.03$, $p = .01$.

The ANOVA also revealed an interaction between condition and type of linking episode, $F(2, 10) = 11.33$, $p = .003$. Teachers produced more linking episodes that involved gestures after receiving instructions regarding the importance of linking ideas through gestures ($M = 26.50$, $SD = 11.55$) than after receiving no instructions ($M = 17.33$, $SD = 7.61$), $t(5) = 2.98$, $p = .03$. Teachers produced fewer linking episodes involving gestures after receiving instructions to inhibit their gesture production ($M = 6.00$, $SD = 5.05$) than after receiving no instructions $t(5) = 3.93$, $p = .01$, or after receiving instructions about the importance of gestures, $t(5) = 4.35$, $p < .001$. In contrast, the number of linking episodes made entirely in speech did not differ across conditions, $F(2, 10) = .217$, $p = .81$. See Figure 3.

Discussion

The purpose of this experiment was to determine whether or not teachers could intentionally alter the gestures they produce during instruction. The results indicate an affirmative answer. Teachers produced more gestures following a tutorial about the effectiveness of gestures than they produced with no instruction. Teachers were also able to inhibit their gestures when asked to do so.

When asked to supplement their lesson with gestures, the teachers specifically increased their pointing gestures, and not their iconic or writing gestures. There are several possible reasons why this differential increase may have occurred. First, the experimenter's tutorial included several examples of how to enhance gestures during the gesture condition. All of the examples were demonstrated with points. Although the experimenter did not explicitly state that points should be used to link ideas, the teachers may have modeled their gestures after those demonstrated by the experimenter, even without explicit instruction to do so. Second, it is possible that the teachers felt that pointing gestures would be the most effective type of gesture when their goal was to use gestures specifically to link ideas. Finally, it is also possible that pointing gestures are the simplest type of gesture to plan and produce, making them the easiest type for teachers to add to their lesson without taxing cognitive resources. These three explanations are not mutually exclusive, and it is possible that all three led to the teacher's preferential use of pointing gestures when they were asked to increase their use of gestures.

The study also suggests that teachers were able to use gestures in specific ways based on the instruction they received. The teachers used gestures specifically to link ideas, as the tutorial had instructed. Teachers linked more ideas with gestures following the tutorial than they did in the baseline condition. This increase of gestures to link information cannot be explained by a general increase in linking episodes, as teachers did not make more links in speech following the tutorial.

In addition to increasing the number of pointing gestures they produced, teachers were also able to inhibit their gestures when asked to do so. Teachers produced far fewer iconic and pointing gestures in the inhibit condition. This

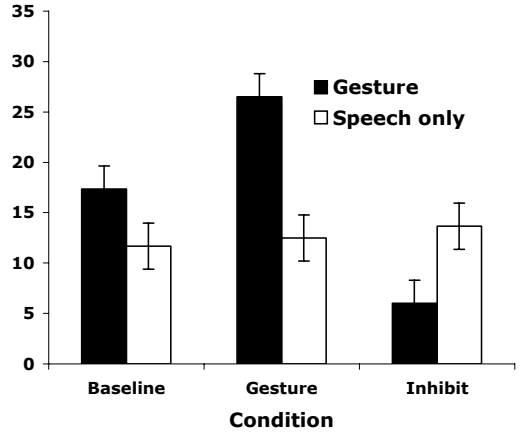

Figure 3. The mean number of linking episodes that contained gestures and that did not contain gestures in each of the three conditions. Error bars were calculated using MS_{error} as the measure of population variance.

evidence converges with the finding that teachers could also increase their gesture production to suggest that teachers can bring their gestures under conscious control. m.li

The results of this study are important for two reasons. First, they suggest that speakers can intentionally control their gestures, and they therefore have implications for theories about the mechanisms that give rise to gesture production. Second, they suggest that interventions involving teachers' gestures are feasible.

The present findings show that speakers can intentionally alter their gesture production. Although these results cannot speak to whether or not gestures are used intentionally in every situation, they do suggest that it is possible for speakers to consciously control their gestures at least in some situations. This adds to existing evidence about how speakers implicitly alter their gestures (Alibali & Nathan, in press; Gerwing & Bavelas, 2004; Melinger & Levelt, 2004; Özyürek, 2002).

More specifically, however, the present results suggest that teachers are responsive to instructions regarding their gesture production, in much the same way that teachers can monitor and control their pedagogical speech. We tend to expect that teachers can direct their speech through training, and indeed, teacher education methods courses are based fundamentally on that premise. This study shows that gestures, like speech, can be similarly controlled. From a pedagogical perspective, this is important, since gestures are an instructional tool that allows teachers to direct learners' attention, build on the students' existing knowledge, and refer to the physical context to ground abstract ideas. However, in order to harness the full potential of gestures, teacher education methods courses and professional development programs may need to include explicit instruction about the importance of using gestures during instruction. The present findings suggest that it is reasonable to expect teachers to alter their gestures based on such interventions.

In conclusion, the present study shows that teachers, and speakers more generally, can bring their gestures under conscious control and use them effectively based on a brief tutorial. Future research is needed to more fully investigate the effects of producing gestures for teachers and students. However, it seems that teachers don't have to just tell their students that ideas are related; they can show them too!

Acknowledgments

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