On the Tip of the Mind: Gesture as a Key to Conceptualization

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Abstract

Why do people gesture when they speak? The reasons are not entirely clear. This paper tests two hypotheses about the role of gesture in speech production: the Lexical Access Hypothesis, which holds that gesturing aids in lexical access, and the Information Packaging Hypothesis, which holds that gesturing aids in conceptualization. Participants were asked to describe dot patterns that were either easy or difficult to conceptualize in terms of geometric shapes. Patterns that were more difficult to conceptualize elicited more gesture than the patterns that were easier to conceptualize. This result supports the Information Packaging Hypothesis.

Introduction

It is often said that a picture is worth a thousand words. In the case of speech production, it sometimes seems that creating pictures with our hands can help our audience understand what we are saying. However, despite the intuitive feeling that we gesture primarily to help our audience, some research suggests that gestures contribute little to an audience's understanding of a gesturer's speech (Krauss, Morrel-Samuels, & Colasante, 1991; Krauss, Dushay, Chen, & Rauscher, 1995; but see Kendon, 1994 for an alternative perspective). Speakers often produce representational gestures even when they know that their audience cannot see them, making it unlikely that their intended purpose is solely to help the audience (Alibali, Heath, & Myers, 2001).

This evidence that gesture does not help comprehension has led some investigators to propose that gesture has a more direct role in the speech production process, by facilitating the planning of speech. Specifically, gesture may play a role in speaking about ideas that are highly spatial or motoric in nature (Kita, 2002; Krauss & Hadar, 2001). It has been shown, for example, that gestures are more likely to coincide with words that are spatial and concrete (e.g., *spin, under,* or *cube*) than with words that are non-spatial and abstract (such as *evil*) (Krauss, 1998; Morsella & Krauss, in press; Rauscher, Krauss, & Chen, 1996). By actively engaging spatial-motoric ideas through gesture, it may become easier to speak about them.

Although gesture may be an overt manifestation of spatio-motoric thought, exactly how gesture may facilitate speech production is still the subject of some debate. The majority of research in this area has followed the speech production model proposed by Levelt (1989), which divides the speech production process into three broad stages: conceptualization, formulation, and articulation. During conceptualization, the prelinguistic thoughts of a speaker are generated and combined into propositional form. During formulation, these thoughts are translated into the appropriate linguistic units by searching through the mental lexicon and identifying the proper lemmas and lexical entries. During articulation, the motor plan for pronouncing the phonemes corresponding to the lexemes is created and executed. It seems unlikely that the production of representational gestures influences motor aspects of articulation, and, indeed, research has typically focused on the earlier stages of speech production (conceptualization and formulation) as the possible beneficiaries of gesture.

Work by Krauss and colleagues (Krauss, Chen, & Chawla, 1996) places the influence of gesture on speech as occurring primarily during the formulation stage. According to their view, referred to hereafter as the Lexical Access Hypothesis, gestures serve as a cross-modal prime to help speakers access specific items in the lexicon. In support of this view, a number of studies have shown that speakers produce more iconic gestures when the words of an utterance are more elusive (e.g. Hostetter & Hopkins, 2002; Morrel-Samuels & Krauss, 1992). For example, when speakers have time to verbally rehearse an utterance, they gesture less than when speaking completely extemporaneously (Chawla & Krauss, 1994). Similarly, speakers gesture more when describing ideas or shapes that are not readily named than when describing ideas or shapes that are easily named (Graham & Argyle, 1975; Morsella & Krauss, in press). Research with aphasic patients also suggests that gesture is involved in the formulation stage. Aphasic patients whose problems are primarily ones of lexical access use more gestures than age-matched controls (Hadar, Burstein, Krauss, & Soroker, 1998). Those whose problems are primarily not ones of lexical access produce fewer gestures than other types of aphasic patients (Hadar, Wenkert-Olenik, Krauss, & Soroker, 1998). Finally, prohibiting speakers from gesturing has been shown to negatively affect speech fluency, especially for speech that is spatial in nature (Rauscher et al, 1996).

Studies that induce tip-of-the-tongue states have yielded slightly less compelling and more contradictory findings about the facilitative effects of gesture on formulation.

Frick-Horbury and Guttentag (1998) found that preventing participants from gesturing increased retrieval failures, whereas Beattie and Coughlan (1998) found exactly the opposite pattern. Participants who were restricted from gesturing actually retrieved more words than those who were allowed to gesture in Beattie and Coughlan's study. In both studies, when participants actually produced gestures, they did not resolve their tip-of-the-tongue states more often than when they did not gesture. Thus, although gestures do tend to co-occur with speech that is spatial and with words that are difficult to find, the claim that gestures actually help the speaker to find the right words remains somewhat unwarranted at this time.

Because Levelt's (1989) speech production model is a stage model, each stage of the production process partly depends on input coming from the previous stage. Articulation cannot begin without at least a minimal amount of characteristic input from the formulator; a word cannot be uttered until it has been decided what word should be uttered. Likewise, formulation and lexical access depend on the output from the conceptualizer. The ideas and propositions that are to be expressed must be available before the correct lemma and lexical affiliate can be searched for and accessed. It would seem therefore that facilitation in the conceptualization process would translate into some facilitation at the lexical level as well. A concept that is clear in the speaker's mind is more readily lexicalized than a concept that is unclear and vague. Thus, the fact that gestures tend to co-occur with words that are spatial and somewhat elusive could also be explained as facilitation at the conceptual level. Gesture may help speakers to clarify or organize their ideas, and this may make the output of the conceptualizer more readily accessible to the formulator. Such a view of gesture is referred to as the Information Packaging Hypothesis (Kita, 2000). According to this hypothesis, gestures help speakers organize knowledge that is spatio-motoric in nature and put it into a verbalizable form. Gesture is thus a mode of thinking, an aid in translating spatio-motoric knowledge into linguistic output. By activating the appropriate bodily representations of spatio-motoric ideas, the ideas can be more fully realized.[1]

Evidence for the Information Packaging Hypothesis comes from studies that have attempted to manipulate the difficulty of conceptualization while holding constant the difficulty of lexical access. Alibali, Kita, and Young (2000) did this with children using a conservation task. They found that children used more representational gestures when they were asked to explain why two items (e.g. two balls of play dough) were different amounts than when they were asked simply to describe how the two items looked different. The words used by the children were highly similar across the two tasks; however, the explanation task required more complex conceptualization than did the description task. The authors argued that children used representational gestures more frequently in the explanation task because of the increased demands on the conceptualizer. Melinger and Kita (2001) found that adults were more likely to gesture in instances where there was a greater choice of what to say, despite the fact that the actual words being spoken in both situations were nearly identical. Again, the authors argued that gesture arises as a result of taxing the conceptualizer rather than the formulator.

Although these studies provide suggestive evidence for the Information Packaging Hypothesis, their conclusions are far from definitive. Although Alibali et al. (2000) found a significant difference in gesture production based on the difficulty of conceptualization, they did not find an especially strong effect. Also, because the study investigated gesture production in children, it may not be appropriate to generalize the findings to adult gesturers. Melinger and Kita's (2001) results suggest an effect in adults. However, they did not report statistical analysis of their data, so it is not clear whether the differences they describe are reliable.

The present experiment was designed to further distinguish between the Information Packaging Hypothesis and the Lexical Access Hypothesis. If gestures do indeed help speakers to conceptualize a spatial situation rather than just helping them to find the right words to describe that situation, then speakers should produce more gestures in a task where there are multiple conceptual options. Similarly, when the task provides only one conceptual option, speakers should produce fewer gestures. However, as long as the words that are ultimately used to describe the situation are the same, the Lexical Access Hypothesis would predict no difference in gesture production regardless of conceptual difficulty.

In order to manipulate conceptual difficulty without affecting difficulty of lexical access, it was necessary to find a task that would result in similar verbal output regardless of the level of conceptual difficulty. For this purpose, we designed a dot description task in which participants were asked to describe patterns of dots to a listener. Patterns of dots were created that could be conceptualized in a number of different ways; that is, a number of different geometric patterns could be imagined to be drawn through each dot pattern. For example, the pattern in Figure 1 could be conceptualized as two triangles, one rectangle with a triangle on top, a five-pointed star, three straight lines, or two parallelograms. This scenario (the dots-only condition) should be more conceptually difficult than a scenario in which the same dot patterns are displayed with lines drawn through them to guide conceptualization (the dots-plus-shapes condition). In both conditions, however, the goal of the participants is to describe only the dots; thus, the words ultimately used by participants should be similar regardless of the conceptual condition in which the dot pattern is presented.

[1] It should be noted that when gestures aid the conceptualizer, they may or may not also aid the formulator. A speaker who is having difficulty finding a particular word may use gesture as a way of clarifying the idea in his or her mind; this may or may not add enough additional information for the formulator to successfully access the lexical affiliate.

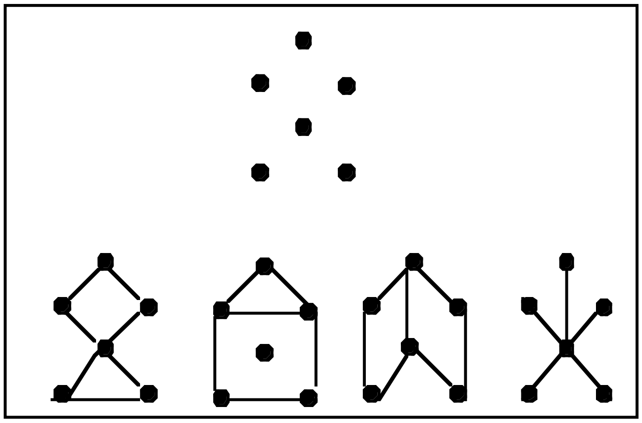

Figure 1: Sample Pattern (top) in Dots-Only Condition and 4 Possible Conceptualizations (bottom)

Method

Participants

Undergraduate students were recruited from the Psychology participant pool at the University of Wisconsin, Madison. A total of 63 individuals (32 males, 31 females) were screened for participation, and those who had not learned English in infancy were excluded. Additionally, one individual was not included because a wrist injury made it difficult for him to gesture. These eliminations resulted in a final sample of 48 individuals (24 males, 24 females) with a mean age of 19.4 yrs (SD = 1.75). Participants did not know that gesture was the focus of the study.

Stimuli

The stimuli were six dot patterns, each of which included 6 to 9 black dots on a white background. Each pattern was designed so that it did not represent the outline of any single geometric shape, but instead afforded a variety of different geometric shapes (see Figure 1). Patterns were created in AppleWorks 6 and loaded into PsyScope for experimental presentation in the conceptually difficult (dots-only) condition.

From each of these six dot patterns, the participants' natural responses in the dots-only condition were used to create patterns for the dots-plus-shapes condition. Each conceptualization provided by the participants in the dots-only condition was transposed onto the appropriate dot pattern by making lines through the dots to indicate the conceptualization pattern. These patterns were also made in AppleWorks 6 and loaded into PsyScope for experimental presentation in the conceptually easy (dots-plus-shapes) condition. All stimulus patterns in both conditions were presented on a Macintosh Powerbook G3 laptop with a 35-cm color screen.

Procedure

Participants were told that the focus of the study was their ability to remember dot patterns that are presented to them for a very short duration and to describe these patterns effectively to another participant. They were told that their descriptions would be audio-taped and played later for another participant who would try to recreate the pattern based on their descriptions. A hidden video camera was focused on the participant throughout the experiment providing a head-on view of the participant from the waist up, and their descriptions were never heard or seen by anyone other than the experimenters. Following their participation, each participant was debriefed regarding the true nature of the experiment and given the opportunity to have his or her videotape destroyed. All declined.

Each participant was brought individually into the testing room, which was divided by a wooden screen. On one side of the screen, a chair was placed in front of a small table (58.5 cm H x 71 cm W x 71 cm L) where the laptop computer was situated. The participant was told to sit in this chair and the experimenter knelt next to the computer and participant to give the instructions and practice trial for the experiment. During instruction, each participant was shown a sample dot pattern and told that patterns similar to it would appear on the computer screen for a very short duration. The participants were told that their task was to describe the pattern as clearly as possible so that the participant who would hear the description via audiotape would be able to successfully reproduce it. Furthermore, they were told that while the task was to get the listener to reconstruct the dots only, they should imagine the dot patterns in terms of geometric shapes and figures. Rather than saying, for example, that there is a dot at the top of the page and another dot about 2 cm below it with another dot directly to the left of that, they should describe the pattern as being a right triangle with dots on each corner with the right angle of the triangle facing toward the left.

Participants in both conditions received two sample patterns that were appropriate to their experimental condition (i.e., patterns shown to dots-only participants contained only dots while patterns shown to dots-plus-shapes participants showed dots with lines drawn to aid conceptualization). During the instructions and example presentations in both conditions, the experimenter produced some small, scripted gestures that were identical across conditions.

Following these instructions, participants in both conditions were asked to complete a practice trial while the experimenter was still present. The experimenter provided feedback as needed based on this practice trial to reemphasize the need to describe the pattern in terms of geometric shapes and to adequately describe the location of the dots within these shapes.

Because the purpose of this study was to manipulate conceptual difficulty without affecting lexical difficulty, measures were taken to assure that lexical access was as easy as possible for participants in both conditions. Following the examples and practice trial, all participants were presented with an alphabetical list of 16 words that seemed likely to occur in descriptions of the patterns. This list included names of geometric shapes as well as spatial and relational prepositions. Each word was displayed in the center of the computer screen for 1200 ms, and participants were asked to pronounce each word out loud as it appeared on the screen. The goal was to have these 16 words primed and readily accessible to participants in both conditions.

After making sure that the participant understood all of the instructions, the experimenter pressed 'record' on the audio-recorder and went to the other side of the wooden screen, where she pretended to prepare for the next part of the experiment. On the experimenter's side of the screen, a table and chair were set up to face away from the participant so that in addition to vision being blocked by the wooden screen, the experimenter was not looking in the same general direction as the participant as he or she described the patterns. While it is difficult to ever definitively rule out the possibility that some gestures produced by the participants were intended for communicative illustration, the presence of the wooden screen, the relative positions of the experimenter and participant, and the participants' naivete regarding the hidden video camera make it highly unlikely that the participants perceived any direct visual audience for their descriptions. Thus the gestures produced by the speakers were most likely for purposes other than direct communicative illustration.

When the participant was ready to begin the first trial, he or she pressed a key on the laptop keyboard. At the beginning of each of the six trials in the experiment, a single black dot was displayed in the center of the computer screen for 2 s as a signal that the stimulus pattern was about to appear. The single dot was then replaced by one of the six dot patterns, which were presented to all participants in the same fixed order. The pattern remained on the screen for 3 s and was followed by a 1 s pause. After this brief pause, a short beep was heard which cued the participant that it was time to begin describing the pattern. When the participant was ready to proceed with the next pattern, pressing any key on the laptop keyboard prompted the beginning of the next trial.

Because it is crucial to the design of this study that the words used by participants in the dots-only condition closely match those used by participants in the dots-plus-shapes condition, each participant in the dots-plus-shapes condition was matched to a participant in the dots-only condition. The responses of the participant in the dots-only condition were used to create the stimuli shown to the matched participant in the dots-plus-shapes condition. Lines and shapes were drawn through each dot pattern to produce a replica of the conceptualization that was described by the dots-only participant. This was done in order to encourage the participants in the dots-plus-shapes condition to conceptualize the pattern in the same way as their dots-only counterpart, and consequently to use similar words to describe the pattern. Because this process necessitated that the stimuli be redesigned and the computer reprogrammed for each dots-plus-shapes participant, 8 participants were completed in the dots-only condition before the patterns were recreated for the dots-plus-shapes condition. Participants were then randomly matched to one of the dots-only participants with gender as the only criterion for pairing; males were always matched to males and females were always matched to females. This pairing procedure was then repeated for blocks of 8 individuals until the final sample of 24 gender-matched pairs (12 male and 12 female) was obtained.

Coding

The descriptions given by each participant were transcribed verbatim, and all iconic gestures were identified. Individual gestures were distinguished from one another by a change in hand shape or motion. For example, a motion straight across from left to right accompanying the words "the bottom line" was coded as one iconic gesture. If a similar movement occurred as the first motion of a sequence in which the hand moved diagonally upward and then diagonally downward without changing hand shape (to imply triangle), this entire sequence was coded as one iconic gesture.

The total number of gestures produced by each participant for each pattern was divided by the total number of words uttered during the participant's description of that pattern. This quotient was then multiplied by 100 to yield the iconic gesture rate per 100 words. Thus, each participant's gesture rate per 100 words was calculated for each of the six pattern descriptions.

Table 1: Frequency of Spatial Terms Used in Each Condition

Dots-Only	Spatial Word	Dots-Plus-Shapes
121	Line	148
116	Triangle	172
110	Top	122
100	Right	67
94	Bottom	124
90	Point	106
72	Middle	78
58	Parallelogram	89
58	Down	45
54	Left	40

Results

Analysis of Speech Produced

To address the question of whether conceptual difficulty affects gesture production separately from the effects of lexical difficulty, it is important that the lexical items being retrieved are similar across conditions. The 10 most commonly used spatial terms used by participants in the dots-only condition are shown in Table 1. Although there is some variation in the exact rank-order of the words, the correlation between the frequency of occurrence of each word in the two conditions is high and significant, $r(8)$ =

0.833, $p < .001$, suggesting that the spatial words used by participants were similar in the two conditions.

Analysis of Gesture Production

The central question of interest in this experiment is whether or not frequency of gesture production is affected by difficulty of conceptualization. The Information Packaging Hypothesis predicts that gestures aid in conceptualization and should thus be used more frequently when conceptualization is more difficult. Alternatively, the Lexical Access Hypothesis predicts that so long as the accessibility of the lexical items being produced remains constant, gesture production should not be affected.

An inherent problem in analyses of gesture production between participants, however, is the fact that there is a large amount of individual variation in the amount of gesture produced by different individuals. Some individuals gesture a lot, while others gesture rarely or not at all. For example, in the current data set, two participants produced an average of more than 16 gestures per 100 words, while eleven others did not gesture at all. This large variation in gesture production between participants necessitates the presence of a very large difference between condition means before a significant effect can be detected. Because of this issue, we analyzed the data using items (i.e., dot patterns) rather than individuals as the unit of analysis. That is, rather than collapsing across patterns and comparing individuals in the two different conditions, data were collapsed across participants and gesture rates were compared for each of the six patterns.

A paired t-test revealed a significant effect of condition on iconic gesture rate ($t(5) = 2.84$, $p < .05$). Patterns in the dots-only condition elicited an average of 5.69 iconic gestures per 100 words ($SD = .81$) whereas the same patterns in the dots-plus-shapes condition elicited an average of 4.79 iconic gestures per 100 words ($SD = 0.26$) (see Figure 2). Thus, gesture rate varied as a function of difficulty of conceptualization, with more gestures produced in the condition with more difficult conceptualization. The distribution of high and low gesturers in each condition suggests that this effect was not driven solely by the presence of a few high gesturers in the dots-only condition.

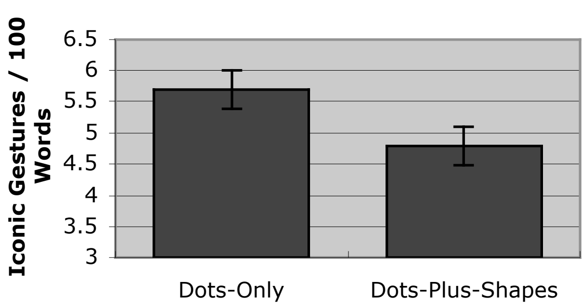

Figure 2: Average Rate of Iconic Gestures/100 Words Produced in Each of the Two Conditions

The dots-only condition included the four participants with the highest gesture rates, but also included four participants who did not gesture at all. The dots-plus-shapes condition also included participants at both extremes, with six who gestured more than 10 times per 100 words and seven who did not gesture at all.

Discussion

The Information Packaging Hypothesis (Kita, 2000) holds that gesture helps refine and organize spatio-motoric concepts so that they can be readily translated into verbalizable units. Alternatively, the Lexical Access Hypothesis holds that gesture primarily aids speech production by priming the appropriate items in the lexicon. The present experiment sought to distinguish between these two hypotheses by varying the conceptual difficulty of a task and observing the extent to which gestures are produced under the two levels of conceptual difficulty.

The difference in gesture rates in the two conditions supports the Information Packaging Hypothesis. Although the difference was small, participants gestured at a higher rate in the dots-only condition, in which they had to produce their own conceptualizations of the stimuli, than in the dots-plus-shapes condition, in which they had the conceptualizations given to them. This finding suggests that gesture does indeed occur not only when lexical access is more difficult, but also when the situation is more conceptually difficult. The present findings do not disprove the Lexical Access Hypothesis, but they do suggest that gesture can serve an earlier stage in the speech production process, above and beyond any benefits it may have at the lexical access stage.

This finding is consistent with current views about the embodied nature of cognition (e.g., Glenberg, 1997). Briefly stated, the central claim of embodied accounts of cognition is that the ways in which we are able to interact bodily with the world profoundly affect the way we think. From an embodied perspective, symbolic representations such as language are grounded or assigned meaning via their links to bodily experiences and actions. It has been shown, for example, that sentence comprehension is affected by how easy it is for the comprehender to mentally simulate him or herself actually performing the actions implied by the sentence (Chambers, Tanenhaus, Eberhard, Filip, & Carlson, 2002; Glenberg & Kaschak, 2002).

If we *understand* language in terms of how we can interact bodily with the world, it seems likely that this same embodied knowledge may also be integral to our ability to *produce* language. Indeed, the present work regarding the role of gesture in conceptualizing and formulating speech seems to point to a role for embodiment in language production. We suggest that the spontaneous gestures produced in the act of speaking are a manifestation of embodied knowledge. Borrowing a phrase from Schwartz (1998), who argued that gestures reflect “physically instantiated mental models”, we suggest that gestures reflect *bodily* instantiated mental models. According to the

Information Packaging Hypothesis, such gestures enhance speakers' abilities to think and speak about those concepts. Thus, when speakers activate their embodied knowledge through gestures, they are better able to express that knowledge in the linear, symbolic system of language.

In conclusion, then, it may very well be that a picture is worth a thousand words; however, the pictures we make with our hands are not only worthwhile for our listeners, but also for ourselves.

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