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Abstract

Several theories of gesture production predict that speech production is affected when gestures are prohibited. The present study sought evidence for these predictions by asking participants to describe how to complete three motor tasks. Half of the participants were prohibited from gesturing during their descriptions. We found that participants who were free to gesture described a higher percentage of key events with semantically rich verbs (e.g., cross, fold) than participants who were not free to gesture. Participants who were free to gesture were also less likely to begin their sentences with the word "and" than participants who were not free to gesture. There were no effects found for other measures of the amount and content of speech produced. Thus, the effects of gesture prohibition on speech production are compatible with the idea that gesturing helps speakers package their thoughts into planning units for speaking.

Keywords: gesture prohibition; speech production

Introduction

Hand gestures that mimic the meaning of speech are frequently produced with descriptions of spatial and motoric events (Alibali, 2005; Krauss, 1998), and they are particularly prevalent with speech describing how to complete motor tasks (Feyereisen & Havard, 1999; Hostetter & Alibali, 2007). This co-occurrence is likely due to the isomorphism between spatio-motor images and representational gestures. Both spatio-motor images and gestures convey meaning globally; the meaning of a particular feature (e.g., handshape) can only be interpreted within the larger meaning of the whole. Similarly, images and gestures both convey meaning synthetically, in that they do not rely on analytic rules like syntax to achieve their meaning (see McNeill, 1992, for discussion).

Because representational gestures rely on the same principles to convey meaning as images, they are a natural means of expressing spatio-motor images during speaking. Rather than having to transfer the global and synthetic properties of mental images into the local and analytic format necessary for speech production, gestures are able to express these properties directly. It seems likely that gesture's ability to directly convey imagistic components of thought may be helpful to speakers who are trying to describe spatio-motor events.

How might gestures be helpful for speakers? A number of possibilities have been considered in the literature. One possibility is that speakers express some aspects of their spatio-motor images in gestures, rather than in speech (e.g., Church & Goldin-Meadow, 1986). Indeed, some data suggests that speakers use gestures to convey information that is not also included in their speech (Melinger & Levelt, 2004). According to this view, speakers use a combination of gestures and speech to express ideas. When one modality (i.e., gesture) is unavailable, speakers may increase their reliance on the other modality (i.e., speech) to fully convey their meaning. This would be manifested in an increase in the information expressed in speech when gestures are not allowed compared to when they are allowed. Indeed, Graham and Heywood (1975) found that speakers used more words to express spatial relations when gesture was prohibited than when gesture was allowed.

However, the opposite prediction is made by other theories that focus on how gestures facilitate speech production. One such theory, the Information Packaging Hypothesis (Kita, 2000), holds that gestures facilitate the packaging of spatio-motor information into the linear format required by speech. Forming an image with the hands can focus attention on particular features of the image to mention, thus helping speakers break their thoughts down in a way that can be linearly segmented. According to this view, speakers who cannot gesture may choose not to speak about spatial information at all. In fact, Rimé, Schiaratura, Hupert, and Ghysselinckx (1984) found through a computerized content analysis that speech produced when gestures were allowed contained a higher degree of vivid imagery than speech produced when gestures were not allowed.

But what happens when a speaker is required to talk about spatial information and is not allowed to gesture? The Information Packaging Hypothesis predicts that such speakers will struggle more to organize their rich spatio-motor ideas in the linear stream of speech. Thus, speakers who cannot gesture may include less spatial information in their speech than speakers who can gesture and they may organize the spatial information they do include less efficiently.

Another theory that focuses on the facilitative benefits of gesture is the Lexical Access Hypothesis (Krauss, Chen, & Gottesman, 2000), which holds that gesture helps speakers to retrieve words that express spatial information. Forming an image with the hands acts as a cross-modal prime to activate the desired word in the speaker's mental lexicon. According to this hypothesis, if speakers are not able to gesture, they may have more trouble finding the words they need to express spatio-motor ideas. In support of this idea, Rauscher, Krauss, and Chen (1996) found that speakers produced a higher proportion of filled pauses (e.g., um, uh) that did not fall at syntactic junctures when they could not gesture than when they could gesture. Non-juncture pauses are considered a sign of trouble accessing lexical items, and Rauscher et al. interpreted their relative increase when gestures are prohibited as evidence that gestures facilitate lexical retrieval.

The purpose of the present study was to further investigate the effects of gesture prohibition on speech production. We asked participants to describe three motor tasks: how to wrap a package, how to tie a shoe, and how to change an automobile tire. Half of the participants were prohibited from gesturing during their descriptions. We tested the effects of gesturing on a number of speech variables to determine if either the amount or the content of speech differed between the two conditions.

If speech and gesture work as mutually compensating channels of expression, then speakers who are prohibited from gesturing should use more detailed speech than speakers who are allowed to gesture, because individuals who cannot gesture will compensate by including more information in their speech. In contrast, if gestures help speakers plan and produce speech, then speakers who are allowed to gesture should use more detailed spatial language than speakers who are not allowed to gesture.

Furthermore, if gestures facilitate speech production by helping speakers package spatio-motor information, then speakers who are prohibited from gesturing should show more difficulty at syntactic junctures than speakers who are allowed to gesture, as these are places where speakers are engaged in conceptual planning of the next syntactic unit. Additionally, speakers who are allowed to gesture should package spatio-motor information into units for speech production in a more efficient way. Thus, when gestures are allowed, the number of spatio-motor terms per speech unit should be higher, and/or the spatio-motor terms should be semantically richer (in either case, the speech expresses spatio-motor information more densely).

Finally, if gestures facilitate speech production by facilitating retrieval of words that express spatio-motor ideas, then speakers who are prohibited from gesturing should produce more filled pauses that are not at syntactic junctures than speakers who are allowed to gesture, replicating Rauscher et al. (1996).

Method

Participants

Twenty-six participants (19 female, 7 male) volunteered to participate. They were recruited via the undergraduate Psychology research pool at the University of Wisconsin-Madison and received extra credit in their Introductory Psychology course in exchange for their participation. All were native English speakers.

Procedure

Participants arrived for testing with a confederate who pretended to be another participant. They were told that they would participate in a study about how people describe spatial information in different situations. No mention was made of the specific focus on the influence of gesture prohibition on speech production. The experimenter pretended to randomly assign the participant to the "speaker" role and the confederate to the "listener" role. The speaker and listener were then seated on either side of a screen, so that they could not see one another.

The experimenter then explained that the speaker would be asked to describe three motor tasks to the listener, who would rate the quality of the descriptions. During the descriptions, the speakers' hands or feet would be immobilized. We chose to restrain participants' feet in the control condition in order to equalize any attentional effects of having to maintain a specific posture across conditions. Participants were randomly assigned to either the feet restrained or hands restrained condition.

Participants in the hands restrained condition were given a 25 x 60 x 2 cm wooden board to place across their laps. On the top of this board, there were several strips of Velcro. The participants were also given cotton gloves to wear that had the opposite side of the Velcro attached to the palms and fingers. They were asked to place their hands on the board, so that the two sides of the Velcro adhered. In this way, they were discouraged from moving their hands during the task without being forcefully restrained. Participants in the feet restrained condition were given a similar wooden board to place underneath their feet. This board was equipped with two straps that the participant slipped over their feet.

Once participants were properly restrained, they were asked to describe how they would complete three motor tasks in the same fixed order. First, they described how they would tie a shoe. Second, they described how they would wrap a package, and finally, they described how they would change a tire on a car. Participants were asked to describe each task in as much detail as they could and to take as much time as they needed.

The experimenter sat across from the participant and listened as each task was described. A hidden video camera recorded the participants' descriptions.

At the conclusion of the experiment, all participants were debriefed about the true purpose of the experiment as well as the hidden video camera. They were given the opportunity to withdraw their video data from the study. All declined.

Coding

The descriptions given by each participant were transcribed verbatim. We then segmented speech into syntactic units. A unit was defined as a main clause and its associated dependent clauses. For example, "You get some wrapping paper/ and you lay it flat on the table" was coded as two units, whereas "You take a piece of paper that is big enough to wrap around the box" was coded as a single unit. We chose the syntactic unit as our level of analysis because each syntactic unit is planned separately (Bock & Cutting, 1982); thus, if gestures facilitate speech planning and production, then gestures should influence speech at the level of the syntactic unit.

Outcome measures

Amount of speech. As a measure of how much the participants in each condition spoke, we counted the total number of words each participant produced during each description. We also counted the total number of units produced.

Speech content. If speakers use gestures to help plan and produce utterances about spatio-motoric information, then speakers who can gesture may produce more spatio-motor terms in speech than speakers who cannot gesture. In contrast, if speakers use gestures to express spatio-motoric information so that it does not have to be encoded in speech, then speakers should convey less spatio-motor information in speech when they are allowed to gesture. To test this prediction, we counted the number of spatial motor terms (SMTs) produced in each description. SMTs were defined as words that denote a spatial or motoric property, relation, or motion. For example, the unit "so they make a little triangle" was coded as containing three SMTs: *make, little*, and *triangle*. Similarly, the unit "um, you wanna take your left shoelace" was coded as containing 2 SMTs: *take* and *left*. We then calculated SMTs per unit.

Participants varied greatly in the SMTs they used to describe individual events. For example, when talking about the first step in tying a shoe, one speaker said "you *cross* the laces over one another" while another speaker said "you *put* one lace over the other." Although we counted both *cross* and *put* as SMTs, these two verbs differ in the amount of specific spatial information they convey, or in their "richness." We therefore decided to more closely examine the verbs speakers used to describe two of the key events from each of the three motor tasks, for a total of six events. From the package-wrapping task, we chose the first folding event, when the paper is first wrapped around the box, and the end-folding event, when the triangle-shaped piece on the end of the box is folded upwards. From the shoe-tying task, we chose the event when the laces are originally crossed and the event when the two laces are intertwined by pulling one through the other. For the tire-changing task, we chose the event when the old tire is taken off and the event when the new tire is put on. Table 1 displays information about the variety of words used to describe each of these key events. We classified each verb as "rich" or "generic" on the basis of whether or not the verb conveyed information about manner or configuration. For example, the term "put" was coded as generic, but the word "cross" was encoded as rich because it conveys specific information about manner (see Breedin, Safffran, & Schwartz, 1998).

Conceptual planning load. According to the Information Packaging Hypothesis (Kita, 2000), gestures help speakers to package their thoughts into units for speaking. According to this view, speakers who cannot gesture may have more trouble deciding which spatio-motor ideas should be

Table 1: Verbs Used to Describe Six Key Events

Task	Event	Number of speakers who described	Most common verb (% who used that verb)	Rich Verbs	Generic Verbs
Tire	Take old tire off	23	Take (57%)	Pull, remove, slide, lift	Take, get, move
Tire	Put new tire on	23	Put (83%)	Replace, slip, place	Put
Shoe	Cross laces	17	Cross (71%)	Cross, criss-cross, pull	Make, put
Shoe	Intertwine laces	21	Put (43%)	Tie, tuck, pull, wrap, loop, cross	Put, bring
Package	Fold over box	26	Fold (62%)	Fold, wrap, lift, cover, place, pull	Put, bring, do, take, make
Package	Fold end up	20	Fold (70%)	Fold, flip, push, pull, square	Take, do, make

Table 2: Speech Output as a Function of whether the Hands or Feet were Restrained

	Gesture Prohibited		Gesture Allowed		*t*	*p*
	M	*SD*	*M*	*SD*		
Amount of Speech						
Words	292.31	107.03	341.46	204.42	0.77	0.45
Units	33.23	10.47	37.38	16.56	1.24	0.22
Content of Speech						
Spatial Motor Terms (SMTs)	76.54	30.52	85.62	46.50	0.59	0.56
SMTs / Unit	2.21	0.46	2.09	0.37	0.69	0.50
% events described with rich verbs	45	36.3	71	27.8	3.87	0.012
Conceptual Planning						
% units starting with "and"	55.2	12.99	38.8	13.5	3.07	0.005
Lexical Access Difficulties						
Filled pauses	9.77	6.38	10.31	9.94	0.16	0.87
% Non-juncture filled pauses	27	19	29	15	0.24	0.81

expressed in what way in each unit. Thus, speakers who cannot gesture may need to spend more time for conceptual planning at the beginning of each utterance in order to make the decisions about what to mention that gesture normally helps with along the way. The need for additional planning time might be manifested by the addition of the word "and" to the beginning of each unit (compare "take them one in each hand/ cross them over/ loop one underneath the other/ pull it tight" to " well you have your two strings/ and crossthem/ and you put one underneath the other one/ and pull 'em tight"). We calculated the percentage of units that began with the word "and" as a measure of speakers' need for additional planning time.

Lexical access difficulties. One implication of the Lexical Access Hypothesis (Krauss et al., 2000) is that speakers should have more difficulty accessing lexical items when they are unable to gesture. Following Rauscher, Krauss, and Chen (1996), we used the proportion of filled pauses that did not occur at syntactic junctures as a measure of difficulties retrieving lexical items. To derive this measure, we first identified all filled pauses (e.g., um, uh, er), and we then classified each as either occurring at a syntactic juncture (e.g., "Uh, first you take one end") or not (e.g., "You wanna take off um the bolts"). For each participant, we then calculated the proportion of filled pauses that were non-juncture filled pauses. We also calculated the total number of filled pauses each participant produced.

Results

Is speech affected when speakers are prohibited from gesturing? To investigate this question, we collapsed the dependent variables described above across the three motor tasks. We then used independent-samples *t*-tests to compare the frequency of each behavior when gestures were allowed and when gestures were prohibited. Table 2 displays the results of all comparisons.

We first compared the amount of speech produced in each condition, by examining the number of words produced and the number of units produced. There was wide variability in how much participants talked, with the total number of words being produced ranging from 99 to 701 words when gestures were allowed and from 149 to 487 words when gestures were not allowed. However, participants who were free to gesture did not produce more speech than participants who were not free to gesture.

We next compared the content of speech when gestures were allowed and when gestures were prohibited. To review, theories that focus on how gesture and speech work together to express information predict more detailed spatial content when gesture is prohibited; theories that focus on how gestures facilitate speech production predict more detailed spatial content when gesture is allowed. There was no difference in the number of SMTs produced in the two conditions (range in gesture-allowed condition: 24-168; range in gesture-prohibited condition: 36-128), nor was there a difference in the rate of SMTs produced per unit of speech. However, a comparison of the percentage of key events described with rich verbs yielded a significant difference between conditions. Speakers who were free to gesture described a larger percentage of the key events with rich verbs (M = 71%, SD = 27.8) than did the speakers who were not free to gesture (M = 45%, SD = 36.3), $t(25) = 3.87$, $p = .012$.

We next considered whether there was evidence that gesture contributes to the conceptual planning of utterances. The Information Packaging Hypothesis holds that gestures help speakers segment spatio-motor ideas into the linear system of speech, and therefore, predicts that speakers should have increased difficulties packaging speech when gestures are prohibited. Packaging problems might result in the production of speech that contains fewer SMTs per unit; however, we found no difference between the SMTs per unit produced by speakers who could gesture and the SMTs per unit produced by speakers who could not gesture. Packaging problems might also result in the need for additional planning time at the beginning of each speech unit, a need that could be met by beginning units with the word "and." We found that speakers who could not gesture were more likely to begin units with the word "and" (M =

55.2%, *SD* = 12.99) than were speakers who could gesture (*M* = 38.8%, *SD* = 13.5), $t(25) = 3.07$, $p = .005$.

We also investigated whether there was evidence for difficulties in lexical access when gestures were prohibited. The Lexical Access Hypothesis holds that gestures help speakers retrieve lexical items, and therefore, predicts that speakers should have increased difficulties retrieving lexical items when gestures are prohibited. However, we found that participants whose hands were restrained did not produce more filled pauses or a higher percentage of non-juncture filled pauses than participants whose hands were not restrained. The total number of filled pauses produced ranged from 2 to 36 by speakers who were free to gesture and from 3 to 22 by speakers who were not free to gesture.

Finally, we more closely examined the behavior of those individuals in the hands free condition who gestured during their descriptions. Three of the participants did not gesture at all during any of their three descriptions. The remaining ten participants gestured from 3 to 33 times over the course of their three descriptions. Rate of gestures per 100 words was not correlated with rate of SMTs or rate of filled pauses. It is worth noting that the findings reported above remain unchanged if the three participants in the gesture-allowed condition who did not gesture are excluded from the analyses.

Discussion

This study aimed to provide evidence about the effects of gesture prohibition on speech production. We tested the predictions of three theories about how speech is affected when gestures are prohibited.

First, some theories posit that speakers use gestures to encode spatial information so that it need not be encoded in speech. Accordingly, these theories predict that speakers will compensate for their inability to gesture by producing more detailed speech when gestures are prohibited. We found no evidence to support this prediction. Speakers did not produce more words, more speech units, or more spatio-motor terms when they were not allowed to gesture than when they were. However, this should not be taken as evidence that such theories of gesture production are invalid. It is still quite possible that speakers do produce gestures and speech as complements to one another. What the present data suggest is that speakers do not compensate for their inability to gesture by enhancing their speech.

Instead, the present data indicate that speakers actually produce less detailed speech when describing spatio-motor events in the absence of gesture. This is manifested in the production of more semantically rich verbs by speakers were allowed to gesture than by speakers who were not allowed to gesture. This is in line with theories that suggest a facilitative role for gestures in the speech production process. Speakers who are able to gesture talk about spatio-motoric events in a more detailed way than speakers who are not able to gesture.

This increased richness of speech content is compatible with two specific theories about how gestures facilitate speech production. First, the Information Packaging Hypothesis (Kita, 2000) holds that gestures are a means of packaging spatio-motor information into the linear system of speech. The Information Packaging Hypothesis predicts that speakers who are unable to gesture should be less successful in packaging spatio-motor information into units for speech production. Accordingly, spatio-motor content was described in a richer way when gestures were allowed compared to when gestures were not allowed.

Second, the Lexical Access Hypothesis (Krauss et al., 2000) can also explain why speakers who were allowed to gesture produced richer speech than those who were not allowed to gesture. The Lexical Access Hypothesis suggests that gestures facilitate the retrieval of words from the mental lexicon. According to this view, speakers should produce less rich speech when they are unable to gesture, because they will have more trouble accessing rich lexical items that are more infrequent in the language. This is in line with the present finding that speakers were more likely to produce rich verbs to describe key events when they were allowed to gesture.

The two theories make different predictions about other aspects of speakers' behavior. The Information Packaging Hypothesis predicts that speakers who cannot gesture should have more trouble at syntactic boundaries, as they decide what to include in the upcoming unit. This prediction was supported by the present data. Speakers whose hands were restricted began a higher percentage of their syntactic units with the word "and" than did speakers whose hands were not restricted. Our claim is that the addition of the word "and" to the beginning of syntactic units is a pausing tactic that gives speakers additional time to plan the rest of the upcoming utterance.

The Lexical Access Hypothesis claims that speakers should produce less fluent speech when gestures are not allowed compared to when they are allowed. More specifically, speakers should produce a higher proportion of non-juncture pauses when they are unable to gesture, because non-juncture pauses are those that are most closely associated with lexical retrieval problems. We found no evidence to support this prediction. The speakers in our study who were unable to gesture did not produce more filled pauses (in total, or at non-junctures) than the speakers who were able to gesture. This is a failure to replicate the findings reported by Rauscher et al. (1996). One possible reason for the discrepancy is the difference in design between the two studies. Rauscher et al. used a within-subjects design that may have been more robust against the natural between-speaker variability in speech fluency.

The two significant findings that emerged in this study are quite subtle. Given the strong predictions made by a variety of theoretical frameworks regarding the inextricable relation between gesture and speech, it is perhaps surprising that we did not find more striking differences in either the amount or the content of speech when gestures were inhibited compared to when gestures were allowed. There are at least

two possible explanations for the lack of more striking effects.

First, prohibiting speakers from gesturing is not an easy task. Rime et al. (1984) found that prohibiting movement of the forearms and hands led to increased movement in other parts of the body, including the eyes, lips, fingers, and legs. Although we did not systematically measure movement in our study, our anecdotal impression certainly coincides with the report given by Rime et al. Speakers have a difficult time being still while they speak; restraining their arms does not keep them from moving other body parts. We consider it quite possible that these non-hand movements accomplish the same functions as do hand gestures, thus potentially weakening our manipulation. However, since we know of no ethical way to completely immobilize a speaker, this problem is not easily overcome.

Second, it is not clear whether all speakers find gestures beneficial for the same reasons or in the same ways. For example, Hostetter and Alibali (2007) suggest that speakers with weak verbal skills may use gestures to facilitate speech production while speakers with strong verbal skills may use gestures to supplement their speech and make speech more engaging. It is possible that inhibiting gestures does have more profound negative effects on speech production than those observed here, but only for speakers with weak verbal skills. In the present experiment, speakers with strong verbal skills who were prohibited from gesturing may have been able to compensate for their inability to gesture by producing more detailed speech. Meanwhile, speakers with weak verbal skills who were prohibited from gesturing may have been unable to compensate for the lack of gesture and produced less detailed, less fluent, and less efficiently packaged speech. However, in the entire sample, such effects may have been washed out by the inclusion of individuals who show both types of patterns. Unfortunately, we do not have information about the verbal skills of the participants in this study, so we cannot test this possibility in the present data.

In conclusion, the present experiment provided new evidence that prohibiting gestures influences speech production. Although we did not find differences in many of the variables we considered, we did find differences in both the richness of the verbs produced and in how easily information was packaged into syntactic units. Thus, we found support for the idea that gesture plays a role in speech production, and specifically, for the idea that gesture facilitates the packaging of spatio-motor information into units. It seems, then, that sitting on your hands does influence your tongue, though it does not make you bite it completely.

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References

Alibali, M. W. (2005). Gesture in spatial cognition: Expressing, communicating, and thinking about spatial information. *Spatial Cognition and Computation, 5*, 307-331.

Bock, K., & Cutting, J. C. (1982). Regulating mental energy: Performance units in language production. *Journal of Memory and Language, 31*, 99-127.

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

Feyereisen, P., & Havard, I. (1999). Mental imagery and production of hand gestures while speaking in younger and older adults. *Journal of Nonverbal Behavior, 23*, 153-171.

Graham, J. A., & Heywood, S. (1975). The effects of elimination of hand gestures and of verbal codability on speech performance. *European Journal of Social Psychology, 5*, 189-195.

Hostetter, A. B., & Alibali, M. W. (2007). Raise your hand if you're spatial: Relations between verbal and spatial skills and representational gesture production, *Gesture,* 73-95.

Kita, S. (2000). How representational gestures help speaking. In D. McNeill (Ed.), *Language and gesture* (pp. 162-185). Cambridge, UK: Cambridge University Press.

Krauss, R. M. (1998). Why do we gesture when we speak? *Current Directions in Psychological Science, 7*, 54-60.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought.* Chicago: University of Chicago Press.

Melinger, A., & Levelt, W. J. M. (2004). Gesture and the communicative intention of the speaker. *Gesture, 4*, 119-141.

Rauscher, F., Krauss, R. M., & Chen, Y. (1996). Gesture, speech, and lexical access: The role of lexical movements in speech production. *Psychological Science, 7*, 226-231.

Rimé, B., Schiaratura, L., Hupert, M., & Ghysselinckx, A. (1984). Effects of relative immobilization on the speaker's nonverbal behavior and on the dialogue imagery level. *Motivation and Emotion, 8*, 311-325.