Linguistic influences on gesture's form

Jennifer Gerwing and Janet Bavelas
University of Victoria

Hand gestures in face-to-face dialogue are symbolic acts, integrated with speech. Little is known about the factors that determine the physical form of these gestures. When the gesture depicts a previous nonsymbolic action, it obviously resembles this action; however, such gestures are not only noticeably different from the original action but, when they occur in a series, are different from each other. This paper presents an experiment with two separate analyses (one quantitative, one qualitative) testing the hypothesis that the *immediate communicative function* is a determinant of the symbolic form of the gesture. First, we manipulated whether the speaker was describing the previous action to an addressee who had done the same actions and therefore shared common ground or to one who had done different actions and therefore did not share common ground. The common ground gestures were judged to be significantly less complex, precise, or informative than the latter, a finding similar to the effects of common ground on words. In the qualitative analysis, we used the given versus new principle to analyze a series of gestures about the same actions by the same speaker. The speaker emphasized the new information in each gesture by making it larger, clearer, etc. When this information became given, a gesture for the same action became smaller or less precise, which is similar to findings for given versus new information in words. Thus the immediate communicative function (e.g., to convey information that is common ground or that is new) played a major role in determining the physical form of the gestures.

Keywords: hand gesture, gesture form, communication, common ground, given/new

Why do conversational hand gestures take on the physical forms that they do? In particular, when gestures represent practical actions that the hands have done previously, they physically resemble those actions, but they do not look exactly the same. For example, the movements of a gesture representing the

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previous action of playing a piano would not be exactly the same as the actual playing. We propose that these differences are systematic rather than idiosyncratic, accidental, or careless changes. The purpose of this research was to investigate systematicity in gesture's form, that is, to examine factors that might predict it. This article will show that some of the variation in gestural form can be accounted for by two linguistic principles that have been shown to influence spoken language: *common ground* and *given versus new* information.

Anything we do with our hands can be classified as being non-symbolic (an action) or symbolic (a gesture). In the simplest sense of "something that stands for something else" (Quine, 1987), a gesture is a symbol; it is a hand movement that stands for something else. Gestural symbols are encoded analogically (e.g., Bavelas & Chovil, 2000), that is, they resemble their referents. However, we propose that the form of a gesture and the action it represents will differ from each other because the function of each is fundamentally different. Actions accomplish something material in a particular setting, while gestures accomplish something communicative within a particular social interaction. Function constrains form: Obviously, an action is constrained by its material purpose; the movements required to play a piece on the piano are dictated by the music the pianist wants to produce. Less obviously, the physical form of a gesture is constrained by its communicative function. A speaker's gesture representing piano playing is constrained by what his or her addressee would recognize at that moment as "playing the piano".

We propose that the gesturer will make two kinds of changes from action to gesture. First, the gesturer needs to be *selective* in the choice of movements, retaining the features that would be necessary (and usually only sufficient) to fulfill the communicative function. Clark and Gerrig (1990) called the selective features of gestures and other demonstrations their *depictive* aspects: the parts that distinguish the intended referent from other possible referents. When gesturers are selective, they are not simply being efficient. They are also eliminating extraneous movements that might obscure the gesture's communicative purpose. A second way in which its communicative function constrains the form and movement of a gesture is the degree of *transformation* required. The gesturer may exaggerate, abbreviate, elongate, or re-orient the movement of the gesture to fit its communicative function at that moment. Thus the physical form of a gesture that represents a previously performed action is constrained by its *immediate communicative function*. Focusing on which features speakers select and transform would simply lead to a list of those features. By studying *when* they do so, that is, what conditions

influence selection and transformation, we can begin to understand some of the principles that guide their choices.

Previous research

Krauss, Chen, and Gottesman (2000) proposed that one of the most important unaddressed inquiries in current research is why different gestures take the particular physical form they do. Most previous experimental research on gestures has followed the tradition of Cohen and Harrison (1973) and Cohen (1977), focusing on changes in the *frequency* or *rate* of gestures as a function of visibility between speaker and addressee. Some experiments have also studied the effects of visibility on the *qualitative* nature of gestures produced (e.g., Alibali, Heath, & Myers, 2001; Bavelas, Chovil, Lawrie, & Wade, 1992; Bavelas, Gerwing, Prevost, & Sutton, 2002). Two less common lines of research are much more relevant to the present study: those that directly examined the relationship between action and gesture and those that examined conversational factors that produce different forms in gestures for the same referent. We will examine these two groups of studies more closely in this section.

LeBaron and Streeck (2000) compared instrumental actions to later gestures produced both by the original actor and by those witnessing the actions. They were investigating how gestural representations emerge from the kinesthetic experience of manipulating objects, that is, the influence of non-symbolic exploratory and instrumental actions on later gestural depictions. They concluded that gestural representation emerges from the knowledge our hands acquire through their experience with objects.

In a pilot study, Gerwing (2003) videotaped pairs of university students doing actions (specifically, individually playing with toys) and then describing these toys to each other, which usually included gestural depictions. The physical form of the gestures differed from the original actions in the ways described above: First, speakers *selected* only particular aspects of the actions they had used previously, eliminating peripheral actions such as picking up the toy from the table, holding it while reading the instructions, or putting the toy away. Second, they *transformed* these selected features. Thus, the gestural depictions often differed from the original action; they were faster or slower than the original action, and they were also larger, smaller, or less precise. An unanticipated finding was that when a speaker continued to describe the previously performed action (and therefore gestured the same action several times),

not only were the gestures different from the original action, they were also *different from each other*. That is, multiple successive depictions of the same referent by the same person had various physical forms. Moreover, the differences between the depictions did not look like haphazard variation. It seemed that the immediate conversational context was systematically influencing the particular form of the gestures; that is, there must be a highly local conversational influence at work.

There is a second group of studies in the literature which focussed, not on the original action, but on how the conversation in which the gestures occur can affect their physical form. Furuyama (2000) studied dyads in which one person instructed the other how to make an origami figure. Because he did not give them paper to fold, they used gestures as well as words. Furuyama found that, when the instructor demonstrated with a gesture, the learner often pointed to, touched, or traced the instructor's gesture. These "collaborative gestures" (pp. 105–106) are obviously determined, at least in part, by the form and placement of the instructor's gesture. Moreover, they only occurred when the instructor had oriented his or her gesture toward the learner, that is, when the particular part of the origami figure that the instructor was talking about at that moment actually faced the learner. Thus, the physical form of some of the learner's gestures was sensitive to interpersonal factors.

Özyürek (2000, 2002) manipulated conversational space. The speaker first viewed a cartoon and then described it to either one addressee (sitting across from the speaker) or two (sitting to the speaker's left and right, forming a triangle). The speaker's gestures representing the same direction in the cartoon changed as a function of addressee location. Özyürek concluded that speakers oriented their gestures in response to the extralinguistic (social) space of the conversation rather than in response to the way they had originally seen the direction in the cartoon.

All of these studies demonstrated conversational influences on gestures' physical form, but there were methodological differences. LeBaron and Streeck's (2000) study and Gerwing's (2003) pilot data examined hands doing actions and then the same hands performing gestural depictions of those actions. Both studies presented comparisons of actions and gestures, albeit without experimental manipulation. Furuyama (2000) and Özyürek (2000, 2002) controlled the task and setting experimentally in order to study specific determinants of gestures' form, but neither of these studies explored the difference between actions and gestures. Furuyama's learners had not made the original actions, and Özyürek compared the gestures not to actions but to the path of an object that

the speaker had viewed in a cartoon. We might learn even more about precisely what is determining the form of the gestures by combining the two methods, that is, by both eliciting the original actions and by experimentally manipulating the conditions in which these actions become gestures.

Rationale and hypotheses

We propose that the determinants of the form of a gesture are a combination of its referent and its immediate communicative function within a particular conversational context. (The latter is a further specification of the broad principle of *recipient design*; Bavelas, Kenwood, Johnson, & Phillips, 2002; Garfinkel, 1967; Sacks, Schegloff, & Jefferson, 1974.) Multiple gestural depictions of the same action would differ because the form of each depiction is constrained not only by the original action but also by the gesture's particular communicative function at the precise moment it occurs. For example, a participant may gesture two versions of an action in quick succession. The function of the first may be to identify what the action was, and the function of the second may be both to draw attention to a particular feature of that action and at the same time to allude to the action as a whole. The function of each gesture is different, so even though the two gestures are both symbolizing the same action, we propose that their form is influenced (and transformed) by subtle differences in their function at that moment.

Note that we are not proposing only a moment-by-moment conversational influence. Obviously, the gesture occurs within an utterance, which is part of the current topic, which occurs in the context of the conversation so far, which is itself occurring within a particular framework that includes the people talking, where they are, and what they are doing there. Thus, a gesture is embedded in cascading levels of conversational context, which help shape many aspects of both the verbal and visible components of interlocutors' communication. These levels of context converge, however, at a precise moment, which determines the gesture's immediate communicative function.

In order to demonstrate a systematic way in which a gesture's immediate communicative function can shape its physical form, we will invoke some principles known to affect such functions. Clark (1992) outlined three principles of discourse, which came out of his work with Haviland in 1977. Although previously applied exclusively to verbal communication, these principles can provide a useful framework for the study of gesture's form:

1. The participants in a conversation work together against a background of shared information (*common ground*).
2a. As the discourse proceeds, the participants accumulate shared information by adding to it with each utterance (*given* information).
2b. Speakers design their utterances so that their addressees can readily identify what is to be added to that common ground (*new* information). (Clark, 1992)

In our terms, the level of common ground that already exists between interlocutors is part of the conversational context, as are the given and new information, which accumulate over the course of the dialogue. We propose that the immediate communicative function (and therefore the precise form) of a communicative act will be determined in part by the status of the referent as common ground (or not) at the beginning of the conversation and its status as given vs. new as the conversation proceeds. The next section describes the background, method, and results of an experiment on the effect of common ground. Then we describe a second analysis of the same data to examine the changes in gestural form for given versus new information.

The influence of common ground

Common ground refers to information that interlocutors share; it provides a background for their conversation and influences how they can refer to things. If interlocutors know that they share common ground about something, a speaker can refer to it elliptically and expect that the addressee will successfully recognize the reference. If they do not share common ground, the speaker's reference will have to be more explicit (i.e., more complex or elaborate) to serve the same function of successful reference. This effect is consistent with two maxims of Grice's co-operative principle (Grice, 1975). First, speakers should refer to things in a *manner* that is clear, easily understood, and orderly, and they should avoid obscurity of expression or ambiguity. Second, according to Grice's maxim of *quantity*, speakers should make their contribution only as informative as required for the current purpose of the exchange. When referring to something, the speaker should give only the minimum amount of information required for the addressee to recognize it. Therefore, if the reference is to something the speaker can presuppose that the addressee already knows, then the minimum amount of required information will be very little. If it refers to something that the speaker and addressee do not share as common ground, the reference will have to contain much more information.

Previous research on verbal reference in spoken language use indicates that interlocutors do take advantage of their common ground to make direct reference as efficient as possible. In Clark and Wilkes-Gibbs's (1986) experiment, speakers and addressees worked together to ensure that direct reference was clear, but they also tried to minimize the amount of collaborative effort required when doing so. Participants' expressions for the same geometric figure changed over repetitions of the task, starting with descriptions and indefinite reference and finishing with standard noun phrases and definite reference. Thus, as they accumulated common ground, the interlocutors became more efficient in their spoken reference, while still being clear (as shown by their accuracy scores).

In an experiment by Isaacs and Clark (1987), pairs of participants had to refer to photos of landmarks in New York City. Participants who were familiar with New York City ascertained quickly whether their partner was equally familiar. If they shared this common ground, they both simply used the proper names of each landmark. If they did not, they referred to the photos using descriptions and longer phrases. Regardless of their level of expertise, the pairs required fewer words and turns over repeated trials of the same task, as they accumulated common ground, just as in Clark and Wilkes-Gibbs (1986). Both of these studies showed that speakers ascertain the minimum that they need to say in order to refer to something and that interlocutors attempt to make their references match the level of common ground they share. Some researchers have discussed this efficiency in terms of energy use (Hunnicutt, 1985; Levy & Fowler, 2000).

Our hypothesis is that the level of common ground shared between participants would influence their gestures in the same way as it has been shown to affect words. Because we were interested in the common ground that participants shared at the outset of a conversation, we focussed on the gestures the participants used for initial identification. We proposed that they would use more elliptical gestures when they knew they shared common ground and more elaborate and complex gestures when they did not. In other words, the gestures used to identify an object when the participants did not share common ground would contain more information (i.e., be more complex or more precise) than those produced when they did share common ground. To test our hypothesis, we manipulated the level of common ground that the participants shared, that is, whether the speaker was describing an object to an addressee who had used the same object or to an addressee who had not. Thus, the gestures used to identify the object would be serving a precise and known

communicative function: they would be helping to identify that object either for someone who had also used it or for someone who had not.

Method

Participants

Sixty-eight first-year psychology students participated in return for one bonus mark (0.5% towards their course grade). We scheduled three participants for each session and excluded the data from analysis when only two arrived. We also excluded the data from one session because of equipment failure. The final *N* was 20 groups, that is, 60 participants (44 women and 16 men).

Equipment

Our Human Interaction Laboratory has four remotely controlled, tightly synchronized Panasonic WD-D5000 color cameras and two special effects generators (a Panasonic WJ-5500B overlaid on a customized Panasonic four-camera system). For analysis, we digitized the data from analog video into AVI format using Broadway software (www.b-way.com) and viewed the digitized data on a 15-inch ViewSonic GS790 color monitor.

Materials

Each participant played with two of five possible toys, which were enclosed in gift bags along with their instructions. We planned to analyze data from only two of the toys, the finger cuff and the whirlygig, which are pictured along with the other toys in Figure 1.

Procedure

When participants arrived, we randomly assigned them to one of three different roles, which determined their seating arrangement and toy assignment; the participants did not need to be aware of these roles at this point. One person in each triad was the target participant for analysis. The roles of the other two created the experimental conditions: they were the common-ground (CG) or no-common-ground (No-CG) participants. Before recording began, the participants consented (in writing) to being videotaped. Then, after getting

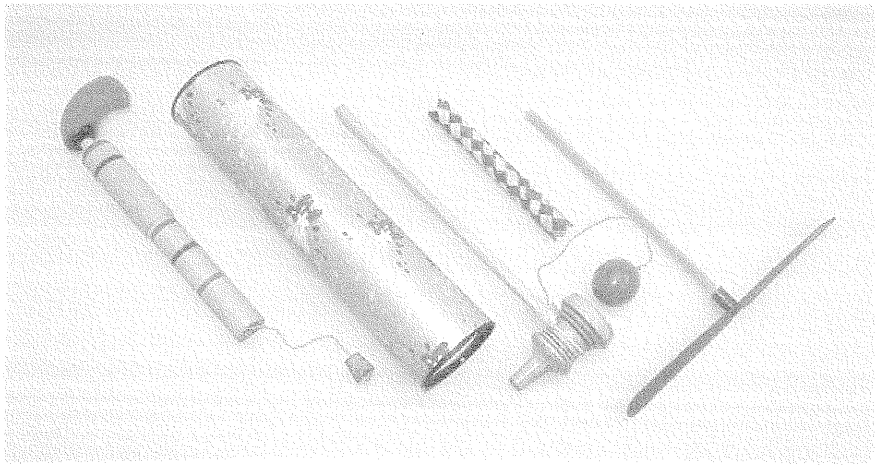

Figure 1. The five toys used in the experiment (from left to right): a popgun, a teleidoscope, a ball and cup, a finger cuff, and a whirlygig.

acquainted, the participants played separately with the toys (Phase 1) and then discussed them in their assigned dyads (Phase 2). Figures 2a and 2b show the split-screen view of each phase.

Phase 1 (individual actions). During Phase 1, the participants could not see each other: The target participant sat at a table on one side of a partition. The other two participants sat on the other side at separate tables, facing away from each other. To ensure that the participants could not see each other's toys, the toys were in gift bags both before and after this phase. The design called for the target and CG participants to play with the same toys (the finger cuff and whirlygig), while the No-CG participant played with a different set. However, the whirlygig proved problematic because of its tendency to fly into the view of other participants when launched too enthusiastically. In order to control common ground, we did not analyze the whirlygig data for groups where this had occurred, and we discontinued using the whirlygig after 15 sessions. For the last few sessions, the target and CG participants played with the finger cuff and a popgun, and the No-CG participant played with a different set of toys. This change maintained the independent variable of common ground (or not), albeit with different subsets of toys.

Phase 2 (dialogue). Once the participants had finished Phase 1 and returned the toys to the gift bags, we asked them to discuss briefly, in assigned pairs, what they "did with the toys". It was essential to the design of the study that the

Figure 2a. Split-screen view of three participants during Phase 1 (action). The target participant is on the top half of the screen, the common ground and no common ground participants are on the bottom half.

Figure 2b. Split-screen view of participants during Phase 2 (dialogue). The target participant is on the left side of the screen and the no common ground participant is on the right.

participants knew whether they shared common ground or not, so at the outset of this phase, we told them which two had played with the same toys and which one had played with a different set.

For each of the three dialogues, the two participants sat facing each other across a coffee table, and the other participant waited outside the lab. First, the target participant talked with each of the other participants, one at a time, then the other two participants talked together. We counterbalanced the order of the target participant's dialogues with the CG and No-CG partners so that any systematic differences in the gestures would not be due to describing the toys for the first or second time.

When the participants had completed the three short dialogues, we explained the purpose of the experiment and their role in it, showed them the videotape of their participation, answered their questions, and asked them to indicate, in writing, various levels of permission to view the data (e.g., permission for analysts to view, permission for showing for professional audiences, etc.).

Analysis 1: Common ground

For the common ground analysis, we created AVI files of the finger cuff discussions from each dialogue. The gestures of interest were those used to identify the toy, that is, those used in the speaker's initial reference to the finger cuff. Therefore, the first step was to locate the exact point at which the interlocutors showed evidence that, as far as they were concerned, the addressee had understood the speaker's reference. We could then create excerpts starting from the initial reference to the finger cuff and ending when the interlocutors appeared to take the identity of the toy as understood. We used criteria from Clark and Wilkes-Gibbs (1986) and ended these excerpts either when the addressee *asserted* acceptance (by saying "yeah" or "right", nodding, or repeating the speaker's gesture) or *presupposed* acceptance (by allowing the speaker to continue with a different topic). Two analysts independently located the end times of each excerpt (i.e., where they thought the participants had grounded in each of the 40 excerpts). The two end times were correlated highly, $r = .997$. The analysts discussed and resolved any discrepancies between end times to define the final excerpts, which were an average length of 4.84 seconds.

For each of the 20 triads, we created an AVI file of the pair of CG and No-CG excerpts in the same counterbalanced order in which they had initially

occurred. We used these files to compare the gestures in the two conditions: In one dialogue, the two participants shared common ground; they had both played with the finger cuff. In the other, they did not share common ground; only the target participant had played with the finger cuff.

In the No-CG condition, the target participant always initiated talk about the finger cuff, because only he or she had played with it. However, in the CG condition, either participant could initiate the description, and we did not wish to impose a speaking order. As it turned out, in 11 triads, the target participant initiated talk about the finger cuff in the CG condition. For these triads, we did a within-subjects comparison: we compared the target participant's finger cuff gestures in one condition to that same participant's gestures in the other condition. In the remaining 9 triads, the other participant initiated talk about the finger cuff in the CG condition. These triads provided data for a between-subjects comparison: we compared the target participant's finger cuff gestures in the No-CG condition to those produced by the third participant in the CG condition.

We hypothesized that, for each triad, the finger cuff gestures in the No-CG condition would be more informative than those in the CG condition. That is, the gestures would have to contain sufficient information to make it possible for the particular addressee to understand the reference. Two analysts independently viewed the pairs of AVI files, in random order, without audio, as many times as necessary. For each triad, they indicated which of the two dialogues contained gestures that conveyed "more information, were more complex, or were more precise". If the analysts considered the gestures equally informative, they could indicate that there was no difference between the two. Reliability was 90%, that is, for 18 of the 20 decisions, the analysts agreed. For the last two, they discussed and resolved the disagreement.

Results

As predicted, gestures produced for the No-CG participant were judged to be more informative, complex, or precise than those produced in the CG condition. In 19 of the 20 groups, the identifying finger cuff gestures in the No-CG condition were judged to convey more information ($p < .001$). In the one exception, the gestures appeared to convey the same amount of information; in no instance was the CG condition judged to convey more information than the No-CG condition. Table 1 summarizes the results for both comparisons (within and between). Included in these data are four CG identification phases

Table 1. Number of clips for each condition that were judged to "convey more information, be more complex, or be more precise."

	Condition in which gestures were more informative			
	No Common Ground	Common Ground	No difference	*p* value (one-tailed sign test)[a]
Within	11	0	0	$<.001$
Between	8	0	1	$=.002$
Total	19	0	1	$<.001$

[a] We evaluated the results statistically with a Binomial Test, using a conservative expected value of .5. That is, judges actually decided between three alternatives (CG, No-CG, or no difference), so one could argue that the a priori probability of choosing the no common ground excerpt was .33, and the probability of choosing one of the other two disconfirming options added to .67. However, we chose to treat the probability of confirming or disconfirming the hypothesis as equal (.5 each), which raised the bar for achieving statistical significance.

that did not include a gesture. When the addressee did not require a gesture to identify the finger cuff, any gesture in the No-CG condition was of course more complex. However, excluding these cases from the analysis did not change the level of significance: 15 of the 16 identification phases from the No-CG condition contained gestures that were judged as being more informative ($p < .001$).

Figure 3. Comparison of gestures in the common ground and no common ground conditions: Demonstrations of pulling action in the finger cuff. Arrows indicate the maximum outward motion.
Left: Common ground condition. Note the curved index fingers and limited range of motion.
Right: No Common Ground condition. Note the straighter fingers and exaggerated range of motion.

Figure 4. Comparison of gestures in the common ground and no common ground conditions: Demonstrations of finger position in the finger cuff.
Left: common ground condition. Note that the index fingers are neither straight nor aligned with each other.
Right: no common ground condition. Note that the fingers are straighter and in a direct line with each other.

Figures 3 and 4 illustrate some differences in gesture shape between the two conditions.

Discussion

The common ground that the interlocutors knew that they shared (or not) systematically influenced the form of their gestures. Although each speaker's initial actions with the toy partially shaped his or her gestures, there was also a significant influence of common ground, that is, the amount of information that would be required for a particular addressee to identify the toy. When the participants shared common ground, the speaker could presuppose the identity of the finger cuff and refer to it using more elliptical gestures. When they did not share common ground, the speaker had to refer to the finger cuff with more elaborate, informative, or precise gestures.

Recall our hypothesis that the immediate communicative function of a gesture imposes constraints on its physical form. Even when they are gesturing previously performed actions, speakers select features of the previous actions and transform them. The result of these transformations is that the physical form and movements of the gesture may appear quite different from the previous action. Our participants used what they knew about their common ground when selecting and transforming features of their previous actions. They selected the features that were necessary (in order to be clear) but also sufficient

(not more than was needed) to fulfill the communicative function of the gesture (Grice, 1975). In other words, they selected the features that would make the referent clear to that particular addressee at the time.

The participants' gestures contained the *depictive* aspects (Clark & Gerrig, 1990) of the finger cuff action, that is, those features that would distinguish the intended referent from *all other possible referents*. In the common ground condition, the set of all possible referents contained two known toys, so the gesture produced to identify one of the toys would only have to be clear enough for the addressee to distinguish it from the other. In one dialogue, the speaker's finger cuff gesture was simply to put the tips of her index fingers together. This gesture was enough for the addressee to distinguish between the finger cuff and the whirlygig. In contrast, for the no common ground condition, the set of all possible referents included a potentially large number of unknown toys, so the gesture would have to be sufficiently informative for the addressee to distinguish that particular toy from any other in the set. Therefore, when the speaker gestured the finger cuff, he would have to depict more of its features. Regardless of the condition they were in, the criterion by which the speakers selected necessary features was that which would distinguish the intended referent from other possible referents.

The influence of given versus new information

In addition to our interest in how the level of common ground at the outset of the conversation influences a gesture's immediate communicative function, we also wanted to consider how the *accumulation* of common ground over the course of the dialogue influences gestures' form. Before information becomes common ground, it is *new* information; it is new to the discourse and serves to expand it (Kess, 1992). Information that accumulates over the course of the dialogue (and thus has become common ground) is called *given* information (Clark, 1992); the speaker can expect that the addressee now knows it. An utterance usually contains some information that can be characterized as "given" and some that can be characterized as "new" (Haviland & Clark, 1974).

Research on verbal reference has shown that speakers can help addressees integrate new information into what has become given by marking the status of both types of information. Speakers can mark verbal information as given or new by using different verbal features. For example, they mark given information by pronominalizing (Chafe, 1974; Kess, 1992), by using definite reference such as "the" (Clark & Wilkes-Gibbes, 1986; Haviland & Clark, 1974; Isaacs

& Clark, 1987; Kess, 1992), or by using restrictive relative clauses and adverbs such as "still", "either", "again", and "too" (Haviland & Clark, 1974). For new information, the speaker can use indefinite reference such as "a" or "an" (Clark & Wilkes-Gibbes, 1986; Haviland & Clark, 1974; Isaacs & Clark, 1987; Kess, 1992) or use fuller descriptions and longer phrases.

Speakers can also mark verbal information as given or new by the use of intonation features (Kess, 1992). Addressees are able to use this prosodic information to identify and integrate the given information into the discourse as a whole (Fowler & Housum, 1987). For instance, speakers systematically attenuate given material by lowering pitch or using a weaker stress (Chafe, 1974; Fowler & Housum, 1987) or by shortening the words referring to given information, often making them unintelligible out of context (Fowler & Housum, 1987; Kess, 1992). Fowler (1988) compared words that speakers repeated in lists versus in meaningful sentences and discovered that the shortening of words depended, not on mere repetition, but on a context of meaningful prose; repeated words were shorter when they were repeated in sentences than when they were repeated in lists. Thus, shortening words appeared to have the communicative function of marking them as given. Speakers also have complementary methods for marking information that is new. They can stress it (Crystal, 1987) or articulate it more clearly, making the words intelligible and recognizable even when isolated from the context of the utterance (Hunnicutt, 1985).

Although research into the effect of the status of information on spoken language reference is well-established, inquiry into how speakers use gesture to indicate given versus new information is much more limited. McNeill (1992) mentioned an association between gestures and the status of information. He described speakers' use of rhythmic hand movements to mark new in contrast to given information in certain discourse contexts. Levy and McNeill (1992) noted that speakers accompanied more discontinuous, unpredictable references with an increased amount of gesturing. When participants described a cartoon, they were more likely to gesture in their initial references to scenes than in later references to the same scenes. Speakers also appeared to use gesturing to distinguish between two types of new information: that which would be important later in the story (marked with gestures) and that which was less important (no gestures). Levy and McNeill suggested that new information should be accompanied not only by more gestures in general but also by gestures of more complexity. Their analysis, however, was limited to the presence or absence of gestures, and they did not expand on any relationship between information status and gesture complexity.

Levy and Fowler (2000) noted that speakers used similar patterns across modalities to mark shifts in topic. Speakers marked new information by not only using lexically long and transparent referring expressions and articulating the words carefully but also by accompanying the words with gesture. In contrast, speakers tended to mark given information by reducing the articulation of a transparent referring expression, using pronouns, and by not using gestures. Levy and Fowler concluded that speakers marked topic change at three levels of description: lexical, articulatory, and gestural. However, they did not expand on how the status of contributed information might affect gestures' physical form.

Thus research on the effect of given and new information on gestures is limited to observations that interlocutors tended to use gestures when contributing new information (especially if the information would be important for later contributions) while they tended not to use gestures when referring to given information. To the best of our knowledge, no research has examined how the physical form of gestures might mark the status of information. We propose that, if speakers mark information as given or new in the choice and articulation of their words, then they should also mark it in the choice and physical form of their gestures.

Analysis 2: Given and new information

For this qualitative analysis, we examined successive gestures in each of 10 whirlygig dialogues, specifically those between the target and the No-CG participants when the latter had not accidentally seen the whirlygig. Because they did not share common ground, the status of information as given or new was most transparent for analysis.

For each dyad, we created AVI files of the relevant dialogue, beginning when the target participant initiated the whirlygig discussion and ending when the two participants finished talking about this toy. After transcribing the spoken words in each excerpt and locating all of the gestures, we focused on the gestures that were directly related to the whirlygig. These gestures included depictions of the toy's physical features (such as the stick, the propeller, its size), the participants' actions (actual actions used during Phase 1), the toy's movements as a result of those actions (such as spinning, flying, falling), and hypothetical or imagined actions (e.g., showing how *not* to spin it). We excluded gestures that depicted anything other than the whirlygig or related actions (e.g., shrugs, interactive gestures[1]).

The analysis required recording two different kinds of information. First, it was essential to divide the information conveyed in each gesture into that which was given and that which was new. Second, it was necessary to record the relationship between gestures over time, that is, the analysis had to show how the accumulation of information over the course of each dialogue manifested in the physical form of successive gestures. Both requirements could be met by devising a grid system that would structure the analysis of each of the 10 whirlygig dialogues (see Appendix A for a prototype grid; see Appendix B for all 10 grids). The first column contains the words that accompanied each successive gesture, and the remaining columns focus on the information in each gesture. The original gesture is in its diagonal cell, that is, the cell where the gesture's column and row intersect. Thus, the sequence of gestures appears in stair steps down the diagonal of the grid. In these diagonal cells, we recorded both the *new* information that the gesture contributed to the conversation (in boldface) and a physical description of the gesture. This first stage of the analysis revealed various strategies that participants used to depict new information, as well as the verbal context of the gesture.

The second stage of the analysis demonstrated how participants depicted *given* information. In the column of cells under each gesture, we recorded two pieces of information: (1) whether and how physical features of the original gesture appeared in each of the subsequent gestures; that is, whether the feature was retained or eliminated; (2) whether the information contributed in the original gesture was conceptually necessary for understanding each subsequent gesture. This part of the analysis indicated how the accumulation of given information over time manifested in the physical form of successive gestures.

Results

Depictions of new information

Recall our hypothesis that, within each gestural depiction, the new information should stand out as the most salient information in the gesture. In analogy to the precise articulation of words marking new information, those aspects of gestures depicting new information should be more precise, life-sized, and well-formed.

The analysis revealed that the new information was indeed more salient in its presentation, and the strategies that participants used were similar to those characteristics we had predicted. Within depictions of the whole whirlygig

action, participants often exaggerated the important feature (e.g., made it larger than life), made it very precise, or drew attention to it with an extra movement. Sometimes they abstracted the salient feature entirely from the whole so that the feature stood on its own. The following example illustrates how a participant made "catching" the most salient feature of the gesture (Appendix B, grid 3):

And you [*just twirl it and catch it*], *that's the idea.*
(1)

(1) Depicts a tiny twirling action followed by life-sized catching motion.

During gesture (1), the speaker portrayed a tiny version of the twirling action (see Figure 5: left) followed by a life-sized, precise catching motion (see Figure 5: right). Although the interlocutors had already established the twirling action earlier, the speaker had not yet discussed catching the whirlygig. "Catching" was the new information depicted in this gesture, and the catching motion's size and precision (in contrast to that of the twirling motion) made it the most salient aspect of the gesture.

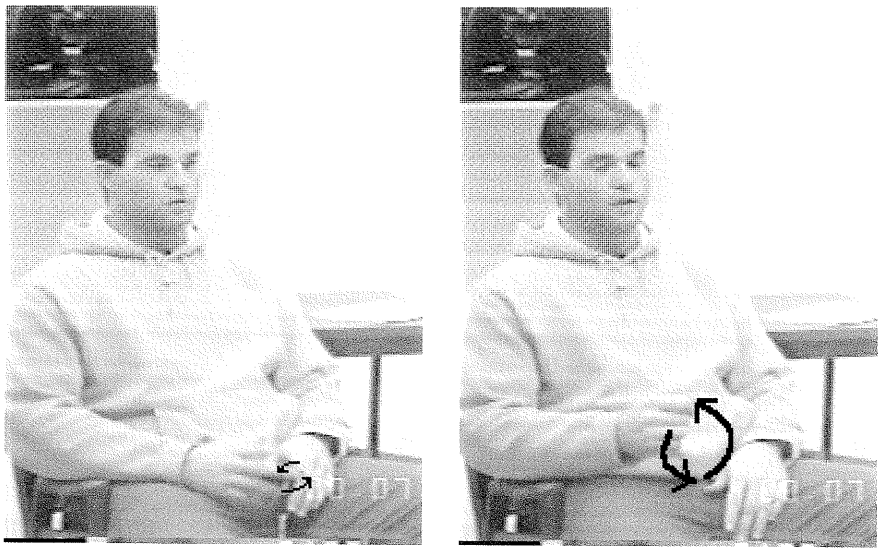

Figure 5. Comparison of gestures depicting given and new information: Demonstrating the whirlygig. Arrows indicate size and range of motion.
Left: The twirling (given) part of the gesture. Note very small depiction of an action that had in fact been much larger.
Right: The catching (new) part of the gesture. Note larger size of action.

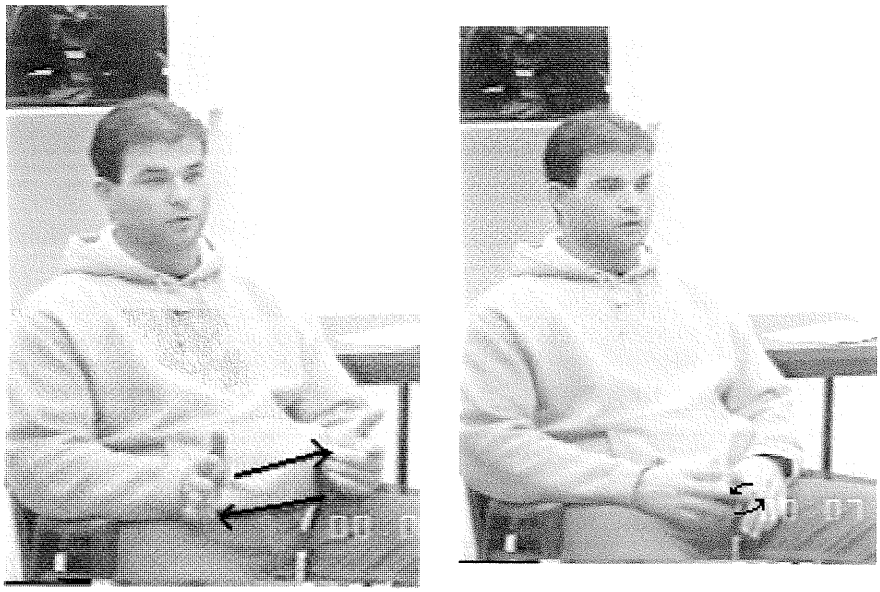

Figure 6. Comparison of gestures depicting given and new information: Two versions of twirling the whirlygig. Arrows indicate size and range of motion.
Left: First gesture, depicting twirling as new information. Note wide separation of both hands.
Right: Later gesture, depicting twirling as give information. Note slight motion of two fingers.

Depictions of given information

We hypothesized that given information, because it could draw on antecedents in previous gestures, would appear as transformed versions of those gestures. Aspects of the gestures depicting given information would be smaller or less precise versions of previous gestures. They might be seen as "sloppier", but we propose that this change is systematic and directly analogous to the "sloppier" articulation of words and serves the same function, namely, to mark the information as given.

In their whirlygig depictions, participants often included physical features from previous gestures in later ones. That is, depictions of information that was once new often emerged, transformed, in later gestures as given information. For example, prior to the above twirling example, the participant had depicted a life-sized version of the twirling motion (see Figure 6: left). In the above example, the gesture re-appeared as a tiny and less precise version. The following descriptions and examples indicate ways in which gestures depicted given information. The location of each gesture is indicated by square brackets.

Although a cursory description is provided for each gesture, only those of particular relevance are described in detail in the text.

Transforming an earlier gesture. Previous gestures, once established as understood, might re-emerge as smaller or less precise features of later gestures (Appendix B, grid 6):

I also had this little like, spinny thing, [*where you went like this*].
(2)
[*And it had like a little propeller thingy on*] [*the top. And it would fly...*]
(3) (4)

(2) Depicts action used to launch the whirlygig

(3) Traces a horizontal circle with downward pointing index finger

(4) Depicts a smaller and incomplete launching action followed by path of toy

Gesture (2) depicted how the participant made the toy fly into the air. In it, the participant's left hand remained stationary, the right hand moved forward, rubbed against and then past the left hand (the release) so that the two hands were no longer in contact (see Figure 7a). During the rubbing part of this gesture, the participant was depicting the action that made the toy spin. When her right hand moved past her left, she was depicting the release of the toy, which was the crucial part of the action that allowed the toy to actually fly up in the air. In gesture (4), the participant again rubbed her right hand past her left, but this time she made the motion much smaller (see Figure 7b: left and middle). She also eliminated the "releasing" aspect of the previous gesture, and instead moved her right hand up into the air to show the direction of the toy (see Figure 7b: right). The beginning, smaller part of this gesture (the rubbing aspect) portrayed the given information in the gesture, and it was a transformed version of gesture (2).

Retaining only spatial information. Although some gestures appeared to disappear physically in later depictions, the space where they had been became relevant to later depictions. In other words, sometimes participants carefully tracked where they had placed previous gestures and placed later ones in the same space. Note, as illustrated in the following example, that the participants did not simply place all the gestures in the space immediately in front of them (Appendix B, grid 8):

Figure 7a. Gestures depicting new information: Two phases of launching the whirlygig.
Left: Beginning of action; participant's right hand starts to rub past the left hand.
Right: End of action; participant's right arm is fully extended.

Figure 7b. Gestures depicting given information and adding new information: Depicting launching the whirlygig (given) and then its flight path (new).
Left: Beginning of action; participant's right hand starts to rub past the left hand.
Middle: End of rubbing action; participant's right arm is not extended (vs. 7a)
Right: Peak of depiction of flight path of toy.

[...*you go like this with one hand*] (5) [*like, I caught it in the air...*] (7) [*and like goes in the air*]. (6) *And I was*

(5) Depicts launching action previously used

(6) Indicates the path of the toy with index finger

(7) Depicts catching the toy

In gesture (6), the participant used her right index finger to indicate the path the whirlygig had taken as a result of her launching action (see Figure 8: left). This gesture began in front of her and ended above and to the right of her head. When she finished this gesture, she brought her right hand back down to below chest level (see Figure 8: middle). In gesture (7), the speaker portrayed the "catching" aspect of her previous actions by extending her right hand back to the exact point where the whirlygig-path gesture had ended (see Figure 8: right). Instead of transforming this earlier gesture to mark given information, this participant placed the later gesture in a space that was relevant and meaningful to the previous gesture.

Eliminating physical features. The previous two descriptions indicated how features of previous gestures were still physically present (transformed or retained spatially) as given information in subsequent gestures. Sometimes aspects of

Figure 8. Gestures that are related spatially: Following the path of the whirlygig.
Left: Participant gestures the peak height of the whirlygig.
Middle: Participant moves her hand down to a resting position in between the two gestures.
Right: Participant moves her hand back up to the first location to depict catching the whirlygig. Note that this new gesture presupposes given information from the first gesture because it catches the whirlygig in its previously depicted location.

previous gestures were not physically present at all in later gestures. These features, although physically eliminated, were still necessary to interpret the new information in later gestures. In other words, information conveyed by the earlier gestures did not cease to be important, even though the physical features of the earlier gestures were no longer present. In the following example, the given information from gesture (8) was essential to the meaning of gesture (11), even though they were not related physically (Appendix B, grid 7):

[*It's like it has a little whirly*]	[*thing at the end,*]	*it's kinda like this,*	[*it's like a "T"*]
(8)	(9)		(10)
[*And then, you spin it…*]			
(11)			

(8) Points up and traces horizontal circle with index finger

(9) Depicts propeller with fingers of right hand

(10) Depicts rod underneath propeller with index finger of left hand

(11) Depicts launching action previously used

In gesture (8), the participant contributed information that the toy had spun in the air by pointing her right index finger up and tracing a horizontal circle. During the next two gestures, her hands moved closer to her body and slightly to the right, so that by the last gesture, her hands were in a different space than they were in the first. In gesture (11), the participant depicted the launching action (one hand rubbing past the other) that she had done with the toy previously. This action was neither a transformation of the first one nor was it in a space relevant to the first. By gesture (11), gesture (8) was physically eliminated. However, the information contributed by (8) was still necessary for understanding (11): the toy spun around as a result of the action that she had performed with it.

Patterns emerging from grid analysis

In summary, the finished grid for each group displays the following information:

1. The diagonal from top left to bottom right indicates the new information in each gesture and how that information was depicted.
2. The column underneath each gesture indicates whether and how that gesture appeared physically in all subsequent ones. It also notes whether the information from that gesture was important for understanding later depictions.

3. The row to the left of each gestural depiction records the accumulated given information from all previous gestures. All of this information potentially contributed to the addressee's interpretation of the new information presented in the gesture at the end of the row.

By keeping track of the residuals of each gesture through all subsequent gestures, the grids revealed two processes. First, physical representations of information faded over time. Just as given information fades prosodically in spoken language reference, given information became less salient physically. As this pattern continued, gestural depictions of given information became more and more schematic over the course of the short dialogue. Later gestural depictions contained fewer (and more sloppily depicted) physical features of the previous gestures. Each gesture's new information, which had been clear and precise at first, became less well articulated in subsequent gestures until it disappeared altogether. The second process subtly complements this trend: Successive gestures carried more and more accumulated or presupposed information. Later depictions, because they were supported by information supplied by previous gestural depictions, became packed with information. These two processes combined to form a systematic pattern in the changing physical form of the gestures. Often the last gestural depiction in each dialogue contained none of the previous physical features but required information from most of them to be understood.

Discussion

The purpose of this analysis was to begin to account for physical differences in successive conversational hand gestures when they had the same referents. The guiding hypothesis was that the physical form of a gesture depends not only on the referent but on the immediate communicative function the gesture is serving at the moment it occurs. To investigate specific communicative functions, this analysis drew a parallel between physical transformations that attenuated or exaggerated aspects of the gesture and the verbal use of prosodic variation to mark given and new information. According to this hypothesis, multiple gestures depicting the same referent (such as portraying an action that the participant had done earlier) would be different if each gesture were serving a slightly different communicative function.

In fact, given and new information in each gesture did explain the changes in its form. Specifically, each gesture made the most important, new information most salient and the given information less salient. Through successive

gestures depicting the same hand action, participants tended to mark given information by making it smaller and less precise and to mark new information by making it larger and more accurate. Thus, through the course of the conversation, gestural depictions of the same hand action became physically more schematic while at the same time becoming more conceptually complex. The physical form of the gestures was indeed influenced by an aspect of communicative function: how the information was to be integrated into the discourse.

Conclusions

The purpose of this research was to expand our knowledge of the factors that determine the form a gesture takes. Clearly, one of those factors must be the referent, which in our data was the original action. However, not all gestures depicting an action are the same as the original action or the same as other gestures for the same action. We proposed that some of these differences are the systematic effects of the immediate communicative function of each gesture, that is, they are a function of the role the feature is playing at a particular moment in the conversation. There are two familiar and related linguistic principles that describe such functions: common ground and given vs. new information. Both have been shown to affect the form of words that describe the same referent, and we tested whether these principles would extend to gestures.

The first analysis studied the effect of common ground between speaker and addressee on the gestures that speakers used to identify an object. As predicted, speakers made gestures that were judged more informative, complex, or precise when their addressee did not share knowledge of the object described than when the addressee did. The second analysis applied the principle of given vs. new information to a series of gestures by the same speaker. When the information was new to the conversation, the part of the gesture depicting this information was more salient, typically because it was larger or more precise. When the same information became given, it faded into the background, becoming less precise, smaller, or less well articulated. Other new information came to the fore by being, for example, well formed, larger, or slower. Thus from the first identifying gestures to the end of the topic, the form of the gesture changed as its function at a particular moment in the conversation changed.

We are not suggesting that the principles of common ground and given vs. new are the only factors other than the referent that shape a gesture's form. We expect that there are other functions waiting to be explored, which can also

have effects. Note, however, that we are emphasizing *function* and not type. Gesture research has produced a large number of taxonomies and typologies over the years, but this approach has two disadvantages. First, "type" is a static property without a clear relationship to the constant dynamic changes of a conversation. Focusing on function rather than category (i.e., on what the gesture is doing at the moment rather than what kind of gesture it is) is more suited to the study of conversational gestures. A second disadvantage is that taxonomies often apparently overlap or even conflict with each other because they imply mutually exclusive types. In contrast, functions are not hegemonic; a gesture can serve more than one function at the same time. For example, the given or common ground gestures in our data both depicted the object and at the same time marked the depiction as information familiar to the addressee.

Finally, our results are consistent with a social theory of gestures, which emphasizes the function of communication to an addressee (e.g., Bavelas, Kenwood, Johnson, & Phillips, 2002; Kendon, 1985, 2000; LeBaron & Streeck, 2000; Özyürek, 2002). Theories that propose a purely individual, cognitive function such as lexical access (e.g., Krauss et al., 2000) would have to predict that the form of the gesture would remain the same for the same speaker or would only vary randomly. The systematic effect of the immediate communicative (i.e., social) context strongly suggests that a gesture is also an interpersonal and not just an intra-personal act.

Notes

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1. Interactive gestures (Bavelas et al., 1992, 1995) have an interpersonal function, in that they refer to the addressee rather than the topic of conversation; their form is typically simple and includes direct orientation of the hand toward the addressee. Typical examples include "citing" the other's contribution and conduit metaphors (McNeill & Levy, 1982).

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Appendix A. Prototype Grid

Gesture numbers listed in top row:

Words accompanying each gesture written in first column:

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4
"words accompanying gesture 1"	**Information contributed by gesture 1 (in bold print)** Physical description of gesture 1 (in regular print)			
"words accompanying gesture 2"	*How physical features from gesture 1 appear in gesture 2 and whether the information contributed by gesture 1 is necessary for understanding gesture 2*	**Information contributed by gesture 2** Physical description of gesture 2		
"words accompanying gesture 3"	*How physical features from gesture 1 appear in gesture 3 and whether the information contributed by gesture 1 is necessary for understanding gesture 3*	*How physical features from gesture 2 appear in gesture 3 and whether the information contributed by gesture 2 is necessary for understanding gesture 3*	**Information contributed by gesture 3** Physical description of gesture 3	
"words accompanying gesture 4"	*How physical features from gesture 1 appear in gesture 4 and whether the information contributed by gesture 1 is necessary for understanding gesture 4*	*How physical features from gesture 2 appear in gesture 4 and whether the information contributed by gesture 2 is necessary for understanding gesture 4*	*How physical features from gesture 3 appear in gesture 4 and whether the information contributed by gesture 3 is necessary for understanding gesture 4*	**Information contributed by gesture 4** Physical description of gesture 4

Physical features from earlier gestures fade into background of later ones →

Information contributed by earlier gestures accumulates and affects interpretation of later gestures →

Appendix B. Ten Grids from Qualitative Analysis

Grid 1

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6	Gesture 7	Gesture 8
"like a plastic, um, stick al(most)."	**Show vertical stick** Fingers trace up and down narrow stick.							
"(al)most with a propeller on it."	*Retained only as spatial reference. Propeller placed on top of virtual stick.*	**Show propeller on top** Fingers point to both ends of propeller.						
"and you have to push"	*Retained only as spatial reference. Whirlygig action performed in same space.*	*Retained only as spatial reference. Whirlygig action performed in same space.*	**Whirlygig action** Including rub and release only.					
"holding your one palm steady you have to..."	*Eliminated physically. Conceptually necessary (stick sits between palms).*	*Eliminated physically.*	*Retained as spatial reference and as left hand position within whirlygig action.*	**Stationary hand** Shows left hand by slapping with right.				
"..."	*Eliminated physically. Conceptually necessary (stick sits between palms).*	*Eliminated physically.*	*Less well formed action: bigger angle between hands and smaller movement.*	*Retained as a more rigid left hand within the whirlygig action.*	**More accurate whirlygig action** Rub and release with stationary hand.			
"push the other one and let it go"	*Eliminated physically. Conceptually necessary (stick sits between palms).*	*Eliminated physically.*	*Even less well formed action: bigger angle between hands and even smaller movement.*	*Eliminated physically. Conceptually necessary (rigid hand important to success of action).*	*Retained only as the less well formed action.*	**Action with release** Rub and more stylized release.		
"go so that it"	*Eliminated physically. Conceptually necessary (stick sits between palms).*	*Eliminated physically. Conceptually necessary (propeller will make it spin).*	*Eliminated physically. Conceptually necessary (rub makes it spin).*	*Eliminated physically. Conceptually necessary (rigid hand helps to make it spin).*	*Eliminated physically. Conceptually necessary (rub makes it spin).*	*Retained only as spatial reference. Spinning path is above whirlygig action.*	**Spinning path of toy** Finger traces circular spinning path.	
"towards you 'cause it might hit your face."	*Eliminated physically. Conceptually necessary (stick sits between palms).*	*Eliminated physically. Conceptually necessary (propeller will make it spin).*	*Eliminated physically. Conceptually necessary (rub makes it spin).*	*Eliminated physically.*	*Eliminated physically. Conceptually necessary (rub makes it spin).*	*Eliminated physically. Conceptually necessary (release to make toy fly in face).*	*Eliminated physically. Conceptually necessary (toy will spin into face).*	**Possible incorrect action** Whirlygig action with other hand.

Grid 2

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6	Gesture 7	Gesture 8
"propeller kind of thing"	**Shows spin** Index finger spins twice pointing slightly forward.							
"it's like a little helicopter"	*Transformed into higher spin that resembles actual spin of whirlygig.*	**Shows spin again** Index finger spins twice pointing up.						
"with like"	*Eliminated physically.*	*Eliminated physically.*	**Junction of stick and propeller** Fingers pinch at where junction would be.					
"you know the"	*Eliminated physically.*	*Eliminated physically.*	*Retained as spatial reference. Top of the toy is where the junction is.*	**Top of toy** Index finger points to top of the toy.				
"top part"	*Eliminated physically. Conceptually necessary (spin happens because of propellers).*	*Eliminated physically. Conceptually necessary (spin happens because of propellers).*	*Retained as spatial reference. Propeller sitting on top of junction.*	*Retained as spatial reference. Propellers at top of the toy.*	**Propellers** Index finger and thumb show location and width of propellers.			
"and then there's ????"	*Eliminated physically.*	*Eliminated physically.*	*Eliminated physically. Conceptually necessary (stick and propeller must be joined).*	*Eliminated physically.*	*Retained as slightly blurry spatial reference. Stick drawn through propellers.*	**Stick** Index finger and thumb show location and width of stick.		
"and you just kinda spin it with your hand."	*Eliminated physically. Conceptually necessary (spin happens when you rub).*	*Eliminated physically. Conceptually necessary (spin happens when you rub).*	*Eliminated physically. Conceptually necessary (stick and propeller must be joined).*	*Eliminated physically.*	*Eliminated physically. Conceptually necessary (propellers spin when you rub).*	*Eliminated physically. Conceptually necessary (stick sits in between hands).*	**Whirlygig action** One rub, stationary hand, release.	
"and it just kinda twirls."	*Transformed into higher spin that resembles actual spin of whirlygig.*	*Transformed into spin with a bigger radius. (more life-sized.)*	*Eliminated physically. Conceptually necessary (stick and propeller must be joined).*	*Eliminated physically.*	*Retained as spatial reference- spin radius matches size of propellers.*	*Eliminated physically. Conceptually necessary (stick between rubbing hands causes spinning).*	*Eliminated physically. Conceptually necessary (the rub caused the spinning).*	**Spin again** Index finger spins slowly five times, pointing up.

Grid 3

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4
"stick with a propeller on it…"	**Stick is vertical, propeller sits on top** Hand pursed as if holding the bottom of a narrow vertical stick.			
"twirl it away…"	*Retained as spatial reference. First whirlygig action portrayed in same space as vertical stick.*	**Prototypical whirlygig action** Includes one rub, right hand moving forward, left hand moving backwards, and release.		
"if you twirl it towards you then it hits you…"	*Eliminated physically. Conceptually necessary. (Need stick between palms)*	*Rub retained but hands not in physical contact. Right hand now moves back and points to speaker.*	**Possible incorrect action** Moving hand rubs towards speaker instead of away.	
"just twirl it and catch it…"	*Eliminated physically. Conceptually necessary. (Can catch vertical stick.)*	*Retained only as one right fingers brushing past left index finger.*	*Eliminated physically.*	**He caught it after doing the action** Tiny whirlygig action followed by a life-sized catch.

Grid 4

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5
"like it had a rod here"	**Vertical stick** Index finger, pointing up, draws a straight vertical line.				
"and then two propellers"	*Retained as spatial reference. Propellers sit on top of stick.*	**Propellers** Index finger draws propellers on top of stick.			
"and you're supposed to go like this"	*Retained as spatial reference. Rub happens where the stick was positioned.*	*Retained as spatial reference. Rub happens with propellers on the top.*	**Whirlygig action** Includes one rub, stationary hand, and release.		
"and it's gonna f- it's supposed to fly"	*Eliminated physically. Conceptually necessary (stick had to be rubbed between palms to make the toy fly).*	*Eliminated physically. Conceptually necessary (propellers make the toy fly up).*	*Retained as spatial reference. Hand starts at end of rub and then rises over whirlygig action.*	**Toy goes up** Hand moves up slightly.	
"but it kept like hitting me."	*Eliminated physically. Conceptually necessary (stick had to be rubbed between palms to make the toy fly).*	*Eliminated physically. Conceptually necessary (propellers make the toy fly up).*	*Retained as hands facing each other. Also same hand moves forward (as with action) while the other goes up towards face.*	*Eliminated physically. Conceptually necessary (toy flies up and therefore could hit face).*	**Toy goes towards face** Hands start palms together then one moves back towards face.

Grid 5

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6	Gesture 7	Gesture 8
A: "I had a, a stick"	**Stick and what happens to it** Hands rub together- not touching.							
"with a propeller on top"	*Retained as spatial reference. Propeller on top of rub.*	**Propeller** Finger circles propeller location.						
"and we're supposed to rub it"	*Transformed into more accurate rub. Hands touching and rub more precise.*	*Retained as spatial reference. Whirlygig action occurs under propeller.*	**Whirlygig action** Including small rub, stationary hand and release.					
"away from"	*Transformed into more accurate rub. Hands touching and rub more precise.*	*Retained as spatial reference. Whirlygig action occurs under propeller.*	*Transformed into more dramatic rub and release.*	**Whirlygig action** Including one big straight rub, stationary hand and big release.				
"my body. And, I guess"	*Transformed into more accurate rub. Hands touching and rub more precise.*	*Retained as spatial reference. Whirlygig action occurs under propeller.*	*Retained completely.*	*Smaller faster rub and release.*	**Spinning toy** Another small whirlygig action followed by spinning path upwards.			
"supposed to spin"	*Transformed into more accurate rub. Hands touching and rub more precise.*	*Retained as spatial reference. Whirlygig action occurs under propeller.*	*Transformed into more dramatic rub and release.*	*Same size but rub not as straight, fingers more spread out and not as held together.*	*Eliminated physically. Conceptually necessary (explains where toy spins and that it happens as a result of action).*	**Whirlygig action** Including big rub, stationary hand and release.		
"…"	*Transformed into more accurate rub. Hands touching and rub more precise.*	*Retained as spatial reference. Whirlygig action occurs under propeller.*	*Transformed into more dramatic rub and release.*	*Same size but rub not as straight, fingers more spread out and not as held together.*	*Eliminated physically. Conceptually necessary (explains where toy spins and that it happens as a result of action).*	*Retained completely.*	**Whirlygig action** Including big rub, stationary hand and release.	
B: why it like, was flying away.	*Eliminated physically. Conceptually necessary (toy flew as a result of action).*	*Eliminated physically. Conceptually necessary (toy flew as a result of location of propellers).*	*Eliminated physically. Conceptually necessary (toy flew as a result of action).*	*Eliminated physically. Conceptually necessary (toy flew as a result of action).*	*Eliminated physically. Conceptually necessary (toy flew as a result of spinning and action).*	*Eliminated physically. Conceptually necessary (toy flew as a result of action).*	*Eliminated physically. Conceptually necessary (toy flew as a result of action).*	**Path of toy** Index finger points from lap, up and to the right, and then back to lap.

Grid 6

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6
A: where you went, like this.	**Portray whirlygig action** Includes rub, stationary hand, and release.					
And it had like a little propeller thingy on	*Retained as spatial reference. Propellers placed on top of where this gesture occurred.*	**Location and motion of propellers** Finger points to propellers spinning.				
the top. And it would fly.	*Whirlygig action now smaller and release aspect eliminated.*	*Retained as spatial reference. Action and consequence occur under propellers,*	**Show consequence of action.** Whirlygig action again with hand showing path of toy.			
B: Was it a top? Oh it went up actually.	*Whirlygig action only a tiny rub with hand in a less precise orientation.*	*Eliminated physically. Conceptually necessary (toy flies because of propellers).*	*Smaller whirlygig action now with pointing finger.*	**Clarify where toy goes** Whirlygig action again with pointing finger showing path.		
A: Yeah, like it would go flying in the air	*Eliminated physically. Conceptually necessary (action made the toy fly).*	*Eliminated physically. Conceptually necessary (propellers make the toy fly).*	*Action eliminated but pointing finger retained.*	*Only pointing finger retained.*	**Confirm where toy goes** Finger points up higher in air	
like I dropped it at the very end.	*Eliminated physically. Conceptually necessary (action made the toy fly, which it had to do before it could fall).*	*Eliminated physically. Conceptually necessary (propellers made the toy fly, which it had to do before it could fall).*	*Eliminated physically. Conceptually necessary (toy followed path upwards before it could fall).*	*Eliminated physically. Conceptually necessary (toy followed path upwards before it could fall).*	*Eliminated physically. Conceptually necessary (toy followed path upwards before it could fall).*	**To show where toy ended up after flying** Thumb points back behind speaker.

Grid 7

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6	Gesture 7	Gesture 8
"It's like, it has a little whirly"	**Spinning** Index finger points up and traces 2 circles.							
"thing at the end"	*Retained as spatial reference. Propeller inside circle.*	**Propeller** Right hand creates shape of propellers						
"it's like a T"	*Eliminated physically.*	*Retained completely*	**Stick and propeller** RH is propeller and Left finger forms vertical stick.					
"and then, you spin it"	*Eliminated physically. Conceptually necessary (spinning happens as a result of action).*	*Eliminated physically. Conceptually necessary (propeller retained as what spins).*	*Retained as spatial reference. Action performed on stick and propeller.*	**Whirlygig action** Including one rub, stationary hand, release.				
"and so, and then it flies"	*Transformed into more spins. Same location bigger size.*	*Eliminated physically. Conceptually necessary (propeller retained as what spins).*	*Retained as spatial reference. Spinning matches size and location of propellers.*	*Retained as spatial reference. Spinning occurs above action.*	**Spinning** Index finger points up and traces 4 circles.			
"K well it flew up"	*Eliminated physically. Conceptually necessary (spinning happens as a result of action).*	*Eliminated physically. Conceptually necessary (propeller retained as what spins).*	*Retained as spatial reference. Action performed on stick and propeller.*	*Transformed into only contact between palms. Rub, stationary hand eliminated. Release symmetrical.*	*Eliminated physically. Conceptually necessary (spinning result of actions).*	**Two whirlygig actions** Including only contact between palms.		
"and…"	*Eliminated physically. Conceptually necessary (spinning makes toy fly).*	*Eliminated physically. Conceptually necessary (propeller retained as what makes toy fly).*	*Eliminated physically. Conceptually necessary (stick and propeller respond to action and make toy fly up).*	*Retained as spatial reference. Path above action.*	*Eliminated physically. Conceptually necessary (spinning makes it go up).*	*Retained as spatial reference. Path above action.*	**Path of toy** Hand points up and to the left.	
"just kept going I'm like "oh""	*Eliminated physically. Conceptually necessary (spinning happens as a result of action).*	*Eliminated physically. Conceptually necessary (propeller retained as what spins).*	*Retained as spatial reference. Action performed on stick and propeller.*	*Only rub retained. Hands in different location, with different orientation.*	*Eliminated physically. Conceptually necessary (spinning result of actions).*	*Only rub retained. Hands in different location, with different orientation.*	*Eliminated physically. Conceptually necessary (toy follows path as result of action).*	**Whirlygig action** Just a rub between fingers.

Grid 8

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4
"a propeller thing"	**Spinning propeller** Index finger draws circle in air.			
"go like this with one hand"	*Retained as spatial reference. Action performed under spinning propeller.*	**Whirlygig action** Including one rub, stationary hand, release.		
"and like goes in the air"	*Retained as spatial reference. Path occurs above spinning.*	*Retained as spatial reference. Path is above action.*	**Path of toy** Index finger points up high.	
"Like I caught it in the air"	*Eliminated physically. Conceptually necessary (spinning makes toy fly so it can be caught).*	*Retained as spatial reference. Catching is above action.*	*Retained as spatial reference. Catching motion is in exactly the same place as end of path.*	**Catching toy** Hand makes a grab for stick part of toy after it flies in the air.

Grid 9

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6
A: "little helicopter"	**Propeller** Hands start at junction of top of stick and go out to represent propellers					
"things with the"	*Retained as right hand sitting at end of the propeller and as spatial reference. Stick in the middle of propeller.*	Stick Left hand draws vertical stick				
"..."	*Retained as spatial reference. Action performed under propeller.*	*Retained as spatial reference. Action performed on stick.*	**Whirlygig action** With two rubs and stationary hand, but no release.			
"Spin"	*Retained as spatial reference. Action performed under propeller.*	*Retained as spatial reference. Action performed on stick.*	*Elaborated with more correct movement.*	**Whirlygig action** Including one rub, stationary hand and release.		
B: "Oh really one of the twirly things"	*Eliminated physically. Conceptually necessary (the propeller spins).*	*Eliminated physically. Conceptually necessary (stick between palms makes toy twirl).*	*Retained as the first half of whirlygig action.*	*Retained as the second half of whirlygig action.*	**Whirlygig action** Including three rubs- one back and forth and one with a proper release	
A: "it and then it"	*Eliminated physically. Conceptually necessary (the propeller spins).*	*Eliminated physically. Conceptually necessary (stick between palms makes toy twirl).*	*Eliminated physically. Conceptually necessary (toy follows path as a result of action).*	*Eliminated physically. Conceptually necessary (toy follows path as a result of action).*	*Eliminated physically. Conceptually necessary (toy follows path as a result of action).*	**Path of toy** Index finger points up.

Grid 10

Words with gesture	Gesture 1	Gesture 2	Gesture 3	Gesture 4	Gesture 5	Gesture 6	Gesture 7	Gesture 8
A: "propeller you spin"	**Spin it between palms** Rubs palms together, hands parallel fingers straight, thumbs up.							
B: "and then"	*Hands not as parallel and fingers not as straight.*	**Abbreviated whirly-gig action** Rub once and release.						
A: "yeah it hit me"	*Eliminated physically.*	*Eliminated physically. Conceptually necessary (released toy flies, hits face.)*	Path of toy One thumb points towards face.					
"sure you rub the palms away"	*Multiple rubs turn into one rub. Hands look the same.*	*Retained with more precise details.*	*Eliminated physically. Conceptually necessary (toy followed path as result.)*	**Prototypical whirly-gig action** Including one rub, stationary hand, release.				
"from you like"	*Multiple rubs turn into one rub. Hands look the same.*	*Retained with more precise details.*	*Eliminated physically. Conceptually necessary (toy followed path as result.)*	*Retained completely.*	**Prototypical whirly-gig action again.**			
"it, yeah"	*Eliminated physically.*	*Eliminated physically. Conceptually necessary (toy took path after whirlygig action.)*	*Retained and elaborated. Instead of one thumb, speaker uses two, bigger movement.*	*Eliminated physically. Conceptually necessary (toy's path after whirlygig action.)*	*Eliminated physically. Conceptually necessary (toy took path after whirlygig action.)*	**Path of toy** With both thumbs.		
"face. I thought I"	*Eliminated physically.*	*Retained with more precise details.*	*Eliminated physically. Conceptually necessary (toy followed this path as result of action.)*	*Retained completely*	*Retained completely.*	*Eliminated physically. Conceptually necessary (toy followed path as result of action.)*	**Prototypical whirly-gig action again.**	
"did it. Hit me"	*Eliminated physically.*	*Eliminated physically. Conceptually necessary (path after action.)*	*Two thumbs not one and less exact. (Smaller and quicker.)*	*Eliminated physically. Conceptually necessary (path after action.)*	*Eliminated physically. Conceptually necessary (path after action.)*	*Thumbs retained but less exact. (Smaller and quicker.)*	*Retained physically-beginning of path gesture is same as end.*	**Path of toy** Thumbs point to face.

Authors' address

Jennifer Gerwing & Janet Bavelas
Department of Psychology
University of Victoria
P.O. Box 3050
Victoria, B.C.
V8W 3P5
Canada

Email: jjg@uvic.ca

About the authors

Jennifer Gerwing, M.A., is a doctoral student in Psychology whose other research interests include the integration of linguistic and paralinguistic features in conversation and the communicative behaviour of individuals with Asperger Syndrome within dyadic interaction.

Janet Bavelas, Ph.D., is a Professor of Psychology who does research on the features of face-to-face dialogue (including gestures) that make it a unique form of language use.