Published in final edited form as:
J Mem Lang. 2010 November ; 63(4): 465–475. doi:10.1016/j.jml.2010.07.002.

Gesturing makes memories that last

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Abstract

When people are asked to perform actions, they remember those actions better than if they are asked to talk about the same actions. But when people talk, they often gesture with their hands, thus adding an action component to talking. The question we asked in this study was whether producing gesture along with speech makes the information encoded in that speech more memorable than it would have been without gesture. We found that gesturing during encoding led to better recall, even when the amount of speech produced during encoding was controlled. Gesturing during encoding improved recall whether the speaker chose to gesture spontaneously or was instructed to gesture. Thus, gesturing during encoding seems to function like action in facilitating memory.

We remember the things we say and the things we do. However, memory for the words we speak is different from memory for the actions we do. Doing an action helps us remember the action (Cohen, 1981; Engelkamp & Krumnacker, 1980; Saltz & Donnenwerth-Nolan, 1981). In contrast, saying a list of words does little to improve our memory for those words (Bahrick & Boucher, 1968; Durso & Johnson, 1980; Paivio & Csapo, 1973). Thus it appears that doing actions leads to more robust memory than simply talking about those same actions. But when people talk, they often gesture with their hands, thus bringing a *doing* component into talking. Does adding a doing component via gesture to speech make the information encoded in speech more memorable than it would have been without gesture?

In principle, there are two moments at which doing an action might influence whether that action is later recalled: doing the action when that action is first *encoded*, or doing the action when it is later *recalled*. Studies of how enactment affects memory typically focus on the effects of doing an action at encoding. In these studies, participants are asked to either act out phrases or to store them verbally in memory for later recall. Phrases that are acted out at encoding are more likely to be subsequently recalled than phrases that are verbally encoded into memory (Cohen, 1981; Engelkamp & Krumnacker, 1980; Saltz & Donnenwerth-Nolan, 1981). Imagining acting out a phrase (Denis, Engelkamp, & Mohr, 1991; Nillson, et. al, 2000) or anticipating acting it out during encoding also improves subsequent recall (Engelkamp, 1997; Koriat, Ben-Zur & Nussbaum, 1990), even when the participant does *not* act the phrase out at recall (Koriat, & Pearlman-Avnion, 2003; see also Engelkamp, Zimmer,

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Mohr, & Sellen, 1994; Koriat & Pearlman-Avnion, 2003; Kormi-Nouri, Nyberg, & Nilsson, 1994). Even seeing someone else perform actions can facilitate subsequent memory for those actions (Cohen, 1981, 1983; Cohen, Peterson & Mantini-Atkinson, 1987; Mulligan & Hornstein, 2003).

Unlike studies of enactment on memory, studies of how gesture affects memory have focused on gesturing at recall rather than gesturing at encoding. Speakers have been found to gesture more when describing a picture from memory than when describing the same picture that is immediately in front of them (Wesp, Hesse, Keutmann, & Wheaton, 2001). Speakers also gesture more when trying to remember infrequent words (which are relatively hard to recall) than when trying to remember frequent words (Beattie & Shovelton, 2000; Krauss & Hadar, 1999). Importantly, speakers' increased gesturing at recall is not just a reflection of the fact that the information is hard to recall—when gesturing at recall is experimentally manipulated, there are increases in the amount of information that speakers remember. Speakers who are told to gesture when trying to recall infrequent words in experimentally induced tip-of-the-tongue states are more likely to recall the words than speakers who are told not to gesture (Frick-Horbury & Guttentag, 1998; although see Beattie & Coughlan, 1999). As a second example, children who are told to gesture as they try to recall an event they have experienced report more details of the event than children who are prevented from gesturing (Stevanoni & Salmon, 2005, although most of the additional details the children produce are in gesture, not speech; in other words, this manipulation does not have a measurable effect on *verbal* memory). Thus, gesturing when trying to recall information may facilitate speakers' access to that information in memory.

The question we address in this paper is whether the gestures that speakers produce when *encoding* information have an impact on whether that information is retained and subsequently recalled. Very little research has been done exploring the effect that gesturing during encoding has on recall. In fact, the only studies that have been done do not manipulate gesturing at encoding, but rather explore naturalistic variation in gesture during encoding. In one study, speakers were permitted to gesture spontaneously when encoding concrete and abstract words. Later, when asked to recall the words, the speakers were either shown videos of gestures that they themselves had produced during encoding, or gestures that someone else had produced. Speakers shown their own gestures recalled more words (and were more likely to retain those words two weeks later) than speakers shown other peoples' gestures or no gestures at all (Frick-Horbury, 2002a, 2002b). These findings suggest that speakers can improve their memory by re-instantiating during recall the gestures that they spontaneously produced during encoding. Note, however, that the studies did not include a group of speakers who did *not* gesture during encoding. Thus, we do not know whether gesturing during encoding has an impact on memory, relative to not gesturing during encoding. Moreover, we do not know whether gesturing during encoding has an effect on memory when gesture is not externally available as a recall cue.

A second study did involve experimental manipulation of gesture at encoding, but explored the role of gesture in maintaining learning rather than maintaining information in memory (Cook, Mitchell & Goldin-Meadow, 2008). In this study, the effect of gesture on learning emerged over time. Three weeks after instruction, children who gestured during learning were much more likely to maintain their learning than children who did not gesture during learning. This study suggests that gesture may be particularly important in influencing memory over time. However, there may be important differences in how gesture works to support learning new mathematical concepts in children vs. how it works to support encoding familiar material in adults.

Our studies address this second question—we ask whether gesturing (as opposed to not gesturing) at encoding affects subsequent recall. Hostetter and Alibali (2008) have proposed that gestures reflect a speaker's action simulations. If so, gestures should have similar effects on memory as overt actions. If gesturing functions as enacting does with respect to memory, then speakers who gesture while encoding should remember more than speakers who do not gesture, even when the gestures are not cued at recall. But there are also reasons to suspect that spontaneous gesturing might not function like enacting with respect to memory. When asked to perform an action during encoding, participants must consciously and overtly translate the verbal instructions they receive into an action plan (Engelkamp, 1991). The process of explicitly translating verbal descriptions into actions during a memory task may be what makes the encoded information memorable. If so, spontaneous gesturing (which seems to be done without overt awareness) might not lead to processing the to-be-remembered information as deeply as following explicit instructions to act, particularly if participants are not actively encoding information into memory. As a result, spontaneous gesturing might not play the same role with respect to memory as enacting.

To explore these possibilities, we asked a group of participants to describe and subsequently recall a series of videotaped events. We examined the relation between spontaneous gestures produced during encoding and subsequent recall of the events.

Study 1

Method

Participants—Seventeen (11 female) undergraduates from The University of Chicago participated in the experiment. Ten of the 17 returned for the delayed memory test approximately three weeks later.[1] All available participants were included in the analysis, but the pattern of findings remains the same if we restrict our analysis to only those participants who completed the entire experiment. Each participant was tested individually and chose to receive either course credit or payment for participating in the study.

Procedure

Encoding phase: Participants were told that the study was about how people communicate events to others. During the encoding phase of the study, each participant viewed 26 short (average 2.7 s) animated vignettes on a computer screen; order of vignettes was randomized across participants. The vignettes involved spatial movements and actions of objects, animals, and people (e.g. a chicken sliding to a policeman; a woman petting a dog; a dove flying into a wheelbarrow; a jogger bending down to touch his toes; a fence swinging shut on its own). The vignettes were previously created to elicit descriptions of motion events in speech and gesture (Goldin-Meadow, So, Ozyurek & Mylander, 2008). The events used in the current study were selected because they tended to elicit gesture in pilot work, with variability across individuals in the amount of gesture elicited. A complete list of the vignettes can be found in Appendix 1. After each vignette, participants were asked to describe to the experimenter what they had just seen in one or two sentences. The participant and experimenter were seated across from each other, with the participant facing the computer. The vignettes were not visible to the experimenter.

Distracter task: After the encoding phase, the experimenter administered a language history questionnaire as a distracter task. Subjects were asked questions about the languages they currently spoke at home and as a child; other languages that they spoke and whether

[1]Participants who returned were not statistically different from participants who did not return on any of our measures of encoding performance.

they had formally learned those other languages at school; whether they had been in a situation where they needed to consistently speak a language other than their native language (e.g. lived in another country, studied abroad); and whether their parents spoke another language.

Immediate Recall: After the language history questionnaire, participants were asked to recall the vignettes they had previously seen and described. Note that participants were not aware that there would be a recall test prior to this point. They were told to recall as many vignettes as possible and to be as specific as they could be. When the participants gave responses that were vague, not specific to certain vignettes, or not clear enough for the experimenter to determine which vignette the participant meant, the experimenter probed the participants. For example, if the participant responded, “I remember there was a dog,” the experimenter would ask, “Do you remember what the dog did?”

Cued Recall: After the participants had finished recalling as much as they could, a cued recall task was administered, containing only items from the experiment. Given that the memory component of this experiment was a surprise, we chose not to include distractors in the cued recall task in order to give participants an opportunity to recall as much as possible. Twenty-six still images displaying the actor in each of the vignettes was shown on the computer screen in a random order. Participants were asked if they remembered seeing each image; if so, they were asked to describe the events or actions associated with the image.

Delayed Recall: A follow-up session occurred approximately three weeks after the initial session (Mean=24.5 days, S.D=1.68). Delayed recall followed the same procedure as immediate recall, and included both free and cued recall. Participants were again unaware prior to the session that memory would be tested at this point.

Coding

Speech and gesture produced at all time points was transcribed and coded. Speech was transcribed verbatim, including filled pauses and hesitations. A particular vignette was considered recalled correctly on each of the memory tests if the speaker's description included the action and at least one other semantic element. For example, in the vignette portraying a man carrying a chicken to some scaffolding, if the participant said, “There was a man carrying a chicken and walking towards something,” the vignette was counted as recalled because the main event (the carrying action) was mentioned, along with two other semantic elements (the actor, man, and the patient, chicken). A vignette was not counted as recalled correctly if the semantic elements were recalled but their roles were reversed. For example, in the vignette portraying a dog sliding to the scooter, if the participant said, “The scooter was sliding to the dog,” the vignette was not counted as recalled correctly even though the dog, scooter, and sliding action were mentioned because the participant had incorrectly identified the dog as the endpoint of the sliding action and the scooter as the moving object. In addition, a particular vignette was not considered recalled correctly if novel items were added. For example, in the vignette portraying a train moving into a fenced corral, one of the participants incorrectly recalled it as a train crashing into a wall.

A gesture was coded when the participant produced any hand movement along with speech that did not serve a functional purpose (e.g. pushing hair back, fidgeting, scratching). Participants produced both representational and beat gestures when describing the vignettes.

A second coder independently coded 10% of the spoken and gestured utterances in order to assess reliability. For speech, agreement between observers for identifying correctly remembered vignettes was 98% (51/52) at immediate recall and 100% (52/52) at delayed recall. For gesture, agreement between observers for coding the presence of a gesture was

92% (48/52) during encoding, 95% (21/22) during immediate recall, and 100% (6/6) during delayed recall.

Results

How often do participants gesture during encoding?—Speakers gestured on 47% (SD=36%) of the vignettes during encoding. For example, when describing a vignette in which a uniformed figure swung a bucket in a circle, one speaker said, "The policeman figure was just spinning the bucket around and around;" he pointed to an empty space in front of his body while saying, "policeman figure," and moved his hand shaped in a fist in circles while saying, "spinning the bucket around and around." When speakers gestured but did not produce representational gestures, they produced beat gestures (small motor movements that do not depict events in the vignette). Both beats and representational gestures were considered gestures in our analyses. However, because few vignettes were described exclusively with beat gestures, the results remain the same if only representational gestures are considered.

Does gesturing during encoding affect immediate and delayed recall?—We next asked whether gesturing during encoding had an impact on how much participants remembered on the immediate and delayed recall tests. We analyzed the items recalled on each test using mixed logistic regression to predict the probability of recalling each item. We chose this analytic approach because it allowed us to account for the considerable variability that we found in how memorable the individual vignettes were. For example, the vignette depicting a fence sliding into place to close a corral was remembered by 70% of the participants at the three-week follow-up test, whereas the vignette depicting a duck flying into a wheelbarrow was not recalled by any of the participants at the three-week follow-up test.

Our model included Gesture (Gesture vs. No Gesture), Test (Free vs. Cued) and Delay (Immediate vs. Follow-Up) and their interactions as fixed factors of interest and Subjects and Items as crossed random effects. The three-way interaction was not significant. There was a reliable interaction between Gesture and Delay ($\beta = .36$, $z=2.7$, $p=.007$) and a reliable interaction between Gesture and Test ($\beta = .27$, $z=2.2$, $p=.03$). The interaction of Test and Delay was not significant. There were also reliable main effects of Test, $\beta = .77$, $z=8.6$, $p<.0001$, and Delay, $\beta = -.72$, $z=7.7$, $p<.0001$. The main effect of Gesture was not significant. As can be seen in Figure 1, participants recalled more items after the delay, and more items on the Free Recall test, when they had previously gestured while describing the items. Thus, spontaneous gesturing seemed to facilitate free recall of information, particularly after a three-week delay.

Does gesturing during encoding affect recall above and beyond speaking?— Of course, when participants gestured during encoding, they were also talking. In fact, participants used more words to describe the vignettes when they gestured during encoding (Mean=17.5, S.D=8.6) than when they did not gesture (Mean=10.7, S.D=2.7). In a mixed effects regression with the log of the words spoken as the outcome variable, Gesture at encoding as the fixed factor of interest, and crossed random subject and item effects, there was a reliable effect of Gesture on the number of words spoken ($\beta = .24$, $t=9.7$, $p<.0001$).[2]

Given this effect, it is possible that the impact of gesture on recall that we see in Figure 1 is actually an effect of words spoken on recall. To explore this possibility, we added the number of words spoken at encoding as a covariate to our recall analysis. The number of

[2]For continuous outcome variables in mixed effects regression, the p values were estimated using MCMC sampling (Baayen, 2008).

words spoken was log transformed prior to inclusion in order to better approximate a normally distributed variable. The interactions of Gesture and Delay (β = .38, z=2.8, p=.004) and Gesture and Test (β = .27, z=2.1, p=.03) were reliable even when the number of words spoken was included as a covariate, as were the main effects of Test (β = .77, z=8.5, p<.0001), and Delay (β = .73, z=7.8, p<.0001). There was also a reliable main effect of the number of words spoken (β = .43, z=2.7, p=.008). Thus, even when the amount speech at encoding was taken into account, gesture at encoding continued to predict improved performance on the free recall test and three weeks after encoding.

These findings provide evidence that gesturing during encoding can facilitate subsequent recall of material, particularly spontaneous recall. However, because gesture was not experimentally manipulated in this study, it is possible that gesture was associated with an underlying factor that supported sustained recall. For example, gesturing during encoding might reflect (rather than cause) particularly deep processing of the materials, or interest and engagement in particular vignettes. In order to make the case that gesture is itself having an effect on long-term recall, gesture needs to be experimentally manipulated.

Study 2

In Study 1, we found that spontaneous gesture was associated with increases in free recall, and increases in free and cued recall three weeks after encoding. In Study 2, we experimentally manipulated participants' gesture during encoding in order to explore whether gesture can play a causal role in participants' memory. One group of participants was asked to gesture as they described the events (*Instructed Gesture*), and a second group was asked to keep their hands still as they described the events (*Instructed No Gesture*). As in Study 1, participants' memory was tested immediately and 3 weeks later.

Method

Participants—A total of 48 undergraduates from The University of Chicago participated in the experiment: 25 (17 females) in the *Instructed Gesture* condition, 23 (17 females) in the *Instructed No Gesture* condition;[3] 43 participants returned for the delayed memory test three weeks later (Mean=21 days, S.D=1.41), 21 in *Instructed Gesture* condition, 22 in the *Instructed No Gesture* condition. All available participants were included in the analysis, but the pattern of findings remains the same if we restrict our analysis to only those participants who completed the entire experiment. Each participant was tested individually and chose to receive either course credit or payment for participating in the study.

Procedure—Participants were randomly assigned to one of two conditions: (1) Participants in the *Instructed Gesture* condition were instructed to use their hands as they described the vignettes during the encoding phase of the study. (2) Participants in the *Instructed No Gesture* condition were instructed not to use their hands as they described the vignettes during encoding. The rest of the procedure was the same as in Study 1.

Coding

Speech and gesture produced at all time points was transcribed and coded as in Study 1. A second coder independently coded 10% of the spoken and gestured utterances in order to assess reliability. For speech, agreement between observers for identifying correctly remembered vignettes was 97% (177/182) at immediate recall and 92% (167/182) at delayed

[3]Three additional participants were eliminated from the study because they did not follow instructions (2 did not gesture when told to, and 1 gestured when told not to) and another participant was eliminated because he had previously seen the vignettes before in an unrelated study.

recall. For gesture, agreement between observers for coding the presence of a gesture was 99% (181/182) during encoding, 98% (82/84) during immediate recall, and 85% (36/42) during delayed recall.

Results

How often do participants gesture during encoding?—Participants in the *Instructed Gesture* and *Instructed No Gesture* conditions did indeed follow our instructions. Speakers in the *Instructed Gesture* condition gestured on 93% (SD=7%) of the vignettes during encoding, whereas speakers in the *Instructed No Gesture* condition gestured on 5% (SD=6%) of the vignettes. Being instructed to gesture did not affect the rate at which representational gestures were produced: 90% of the trials with gesture in the *Instructions* condition included representational gesture, compared to 82% of the trials with gesture in Study 1.

Does instructed gesturing during encoding affect immediate and delayed recall?—We next asked whether instructed gesturing during encoding had an impact on how much participants remembered. Figure 2 depicts the average proportion of items recalled on each test, as a function of experimental condition.[4] We again analyzed the probability of recalling each item using mixed logistic regression, with Gesture Condition (Gesture vs. No Gesture), Test (Free vs. Cued) and Delay (Immediate vs. Follow-Up) and their interactions as fixed factors of interest and subjects and items as crossed random effects. The three-way interaction was not significant. There was a reliable interaction between Gesture and Test ($\beta = .08$, $z=2.4$, $p=.01$) and reliable main effects of Test ($\beta = .38$, $z=11.8$, $p<.0001$) and Delay ($\beta = -.49$, $z=14.5$, $p<.0001$). As can be seen in Figure 2, participants in the Gesture Condition recalled more items on the Free Recall test, both immediately and after a delay.

Does gesturing during encoding affect recall above and beyond speaking?—There was again a relation between whether or not participants had gestured during encoding, and the number of words spoken during encoding. In a mixed regression model with the log of the words spoken as the outcome variable, Gesture Condition as the factor of interest, and crossed random subject and item effects, there was a reliable effect of Gesture ($\beta = .15$, $t=2.8$, $p=.005$). Accordingly, we again explored whether verbal encoding could account for our effects using a mixed regression model with Gesture Condition (Gesture vs. No Gesture), Test (Free vs. Cued) and Delay (Immediate vs. Follow-Up) and their interactions as fixed factors of interest, log of words spoken as a covariate, and subjects and items as crossed random effects. There was a reliable interaction between Gesture and Test ($\beta = .08$, $z=2.4$, $p=.01$) and reliable main effects of Test ($\beta = .38$, $z=11.8$, $p<.0001$) and Delay ($\beta = -.49$, $z=14.5$, $p<.0001$) even when the number of words spoken was included as a covariate. There was also a reliable effect of the number of words spoken ($\beta = .20$, $z=2.3$, $p=.02$). Thus, when the amount spoken at encoding was taken into account, gesture at encoding continued to predict free recall.

These findings suggest that, like enactment, gesture can facilitate encoding of information into long-term memory. However, the pattern of performance was not quite the same as seen in Study 1. In Study 1, there was an interaction between gesture and test—the effect of gesture on recall was seen primarily on the follow-up free-recall test. But in Study 2, there was a main effect of gesture—the effect of gesture was seen on the free recall test both immediately and after the three week delay. One possibility is that the instructions to gesture

[4]We included all trials, even those on which participants did not follow our instructions. The pattern of results does not change if we include only those trials on which participants followed the experimental instructions.

may have made gesture function more like enactment. Studies of enactment typically report effects on immediate recall, comparable to the effects we saw in Study 2. But the pattern of performance seen in Study 2 is not entirely consistent with the effects typically found in an enactment paradigm. The effects of enactment are not observed after a two-week delay (Manzi & Nigro, 2008). In contrast, in both Study 1 and Study 2, gesture was associated with improved free recall after a three-week delay.

Studies of enactment also typically report effects on cued recall as well as free recall. In contrast, we found effects of gesture only on free recall. It is important to note, however, that our cued recall task was different from the cued recall tasks typically used in studies of enactment. In studies of enactment, cued recall usually includes both correct and lure items. As mentioned earlier, we were concerned that including lure items in the cued recall test might introduce additional difficulty into the follow-up recall test; we therefore did not include lure items in our cued recall tests. Moreover, our cued recall test was based on a visual image rather than verbal material, which may have changed both the salience of the cue and how the cue affected subsequent recall. Pictures are generally more memorable than words (Paivio, 1969); it is therefore possible that the cued recall test in our studies acted as an additional encoding cue and contributed to the effects observed on long-term recall in Studies 1 and 2. Accordingly, in Study 3, we eliminated the cued recall test.

Moreover, studies of enactment have focused on the role of enactment in memory for everyday actions that are usually performed with the hands (e.g., blowing a whistle), rather than the types of motion events used in our study (e.g., a man carrying a chicken to a scaffold). We explored the role of the nature of the to-be-remembered material in Study 3, using materials and instructions like those typically used in studies of enactment.

Study 3

In Study 3, we again asked whether the gestures speakers produce when encoding events have an impact on immediate and long-term memory. However, this time we studied the kinds of events that are typically used in studies of enactment effects on memory—everyday actions that are usually performed with the hands.

Method

Participants—A total of 41 (20 females) undergraduates from The University of Chicago participated in the experiment; 34 participants returned for the delayed memory test three weeks later (Mean=21.19 days, S.D=.81), 16 in *Instructed Gesture* condition, 18 in the *Instructed No Gesture* condition. All available participants were included in the analysis, but the pattern of findings remains the same if we restrict our analysis to only those participants who completed the entire experiment. Each participant was tested individually and chose to receive either course credit or payment for participating in the study.

Procedure—The procedure was generally the same as in Studies 1 and 2. The only changes were the nature of the stimuli used, and the fact that we did not include a cued recall task. Participants described 36 short videos of a man engaged in a variety of everyday actions (e.g. blowing a whistle, flattening a plasticene, rolling a pencil, etc). A complete list of the actions used can be found in Appendix 2. The actions used were taken from stimuli used to elicit the enactment effect in previous studies. As in Study 2, one group of participants was asked to gesture as they described the events (*Instructed Gesture*), and a second group was asked to keep their hands still as they described the events (*Instructed No Gesture*).

Results

How often do participants gesture during encoding?—Participants again followed our instructions. Speakers in the *Instructed Gesture* condition gestured on 99% (SD=9%) of the vignettes during encoding, whereas speakers in the *Instructed No Gesture* condition gestured on 3% (SD=16%) of the vignettes.

Does instructed gesturing during encoding affect immediate and delayed recall?—We next asked whether instructed gesturing during encoding had an impact on what participants remembered. The left panel of Figure 3 depicts average performance on the memory tests as a function of gesture condition. We again analyzed results using mixed logistic regression models to explore the probability of recalling each item, with random subject and item effects and Delay and Gesture as factors of interest. The interaction of Delay and Gesture was not significant. There was a main effect of Delay ($\beta = -.62$, $z=12.9$, $p<.0001$). The effect of Gesture was not reliable.

Does gesturing during encoding affect recall above and beyond speaking?—We again explored the relation between gesture condition and saying more per vignette, using a mixed regression model with the log of the words spoken as the outcome variable, Gesture Condition as the factor of interest, and crossed random subject and item effects. Unlike our previous studies, there was no effect of Gesture Condition on the log of the words spoken ($\beta = .08$, $t=.855$). Nonetheless, in keeping with previous analyses, we again explored whether accounting for the number of words spoken would change the pattern of results. There were reliable main effects of number of words spoken ($\beta = .19$, $z=2.5$, $p<.01$) and Delay ($\beta = .62$, $z=13.0$, $p<.0001$). The main effect of Gesture and the interaction between Gesture and Delay were not significant. Thus, unlike Study 1 and Study 2, there was no effect of gesture on recall, either immediately after encoding or over time. Instead, variation in recall for events was explained by variation in the amount spoken during encoding.

These findings suggest that, unlike enactment, gesturing during encoding may not facilitate recall of everyday actions performed with the hands. However, before coming to this conclusion, we must consider one additional factor. Previous research using the enactment paradigm has shown that *observing* actions produced by someone else can, at times, result in a memory benefit comparable to the benefit associated with producing one's own actions (Cohen, 1981, 1983; Cohen, Peterson & Mantini-Atkinson, 1987; Mulligan & Hornstein, 2003). It is therefore possible that observing videos of a person engaged in simple actions itself facilitates recall, thus obscuring any beneficial effects that gesturing about these actions might confer. To test this hypothesis, in Study 4, we used static images taken from the videos used in Study 3 to eliminate overt manual action from the to-be-remembered stimuli.

Study 4

In Study 4, we again asked whether the gestures speakers produce when encoding action events have an impact on memory. However, this time we avoided providing participants with dynamic action information in the to-be-remembered materials. Rather than describe video clips of an actor performing hand actions, participants described still images of the same hand actions used in Study 3.

Method

Participants—A total of 15 (8 females) undergraduates from The University of Chicago participated in the experiment. All participants returned for the delayed memory test two weeks later (Mean=13.6 days, S.D=2.75), 8 in *Instructed Gesture* condition, 7 in the *Instructed No Gesture* condition.5 Each participant was tested individually and chose to receive either course credit or payment for participating in the study.

Procedure—The procedure was the same as in Study 3. The only change was the nature of the stimuli used. Participants described 36 images of a man engaged in a variety of everyday actions; the images were taken from the videos used in Study 3. As in Studies 2 and 3, one group of participants was asked to gesture as they described the events (*Instructed Gesture*), and a second group was asked to keep their hands still as they described the events (*Instructed No Gesture*).

Results

How often do participants gesture during encoding?—Participants again followed our instructions. Speakers in the *Instructed Gesture* condition gestured on 98% (SD=13%) of the vignettes during encoding, whereas speakers in the *Instructed No Gesture* condition gestured on 1% (SD=11%) of the vignettes.

Does instructed gesturing during encoding affect immediate and delayed recall?—We next asked whether instructed gesturing during encoding had an impact on what participants remembered. The right panel of Figure 3 depicts average performance on each of the memory tests as a function of gesture condition. We again analyzed results using mixed logistic regression models to explore the probability of recalling each item, with random subject and item effects and Delay and Gesture as factors of interest. The interaction of Delay and Gesture was not significant. There were reliable main effects of Gesture ($\beta = .30$, z=2.6, p=.009) and Delay ($\beta = .64$, z=8.4, p<.0001).

Does gesturing during encoding affect recall above and beyond speaking?—We again explored the relation between gesture condition and saying more per vignette, using a mixed regression model with the log of the words spoken as the outcome variable, Gesture Condition as the factor of interest, and crossed random subject and item effects. There was again no effect of Gesture on the log of the words spoken ($\beta = -.08$, t=.61). Nonetheless, in keeping with previous analyses, we again explored whether accounting for the number of words spoken would change the pattern of results. There were reliable main effects of Gesture ($\beta = .31$, z=2.6, p=.009) and Delay ($\beta = .65$, z=8.4, p<.0001). The main effects of the number of words spoken was not significant ($\beta = .009$, z=.95). The interaction between Gesture and Delay was not significant. Thus, like Studies 1 and 2, there was a reliable effect of gesture on free recall, both immediately and after a delay.

Why do we see an effect of gesturing at encoding when participants recall static images and not when they recall dynamic video? As hypothesized earlier, it is possible that watching someone perform an action may, on its own, activate motor representations; on this view, gesturing at encoding does little to further activate these representations. In contrast, activating motor representations in response to a still image of an action may require facilitation—facilitation that gesturing seems to be able to provide. This hypothesis is based on the assumption that, overall, recall is better with the video stimuli than with the picture stimuli, which does seem to be the case in our data. Indeed, as can be seen in Figure 3, recall of the pictures at follow-up after gesturing during encoding (26%) was as good as recall of the videos with or without gesturing during encoding (23%, 21%, respectively); the outlier was recall of the pictures without gesturing during encoding (15%).

5Participants returned after two weeks in this study (rather than three weeks as in Studies 1–3) because the data were collected at the end of the academic quarter, and we wanted to increase the likelihood of participants returning for the follow-up session.

General Discussion

We have found that gesturing while encoding an event can affect subsequent memory for that event. Across three studies, gesturing during encoding was associated with increases in free recall, both immediately and after three weeks. These findings suggest that gesturing during encoding may influence the way that information is *stored* in memory, adding to previous findings that gesturing during recall can influence the way that information is *recalled* from memory (Frick-Horbury, 2002a, 2002b; Frick-Horbury & Guttentag, 1998; Stevanoni & Salmon, 2005). Our findings are generally consistent with previous research suggesting that enacting phrases during encoding can facilitate memory for those phrases (Cohen, 1987; Engelkamp, Zimmer, Mohr, & Sellen, 1994; Mulligan & Hornstein, 2003). Moreover, the current findings extend these results to visual depictions of actions, both simple events and actions typically performed with the hands. Our findings are thus consistent with the suggestion that gestures may reflect speakers' action simulations (Hostetter & Alibali, 2008; see also Beilock & Goldin-Meadow, 2010; Cook & Tanenhaus, 2009; Goldin-Meadow & Beilock, 2010).

The findings are also largely consistent with previous work suggesting that gesture can facilitate learning over time. When children gesture while learning a mathematical concept, they are particularly likely to maintain what they have learned (Alibali & Goldin-Meadow, 1993; Cook & Goldin-Meadow, 2006; Cook, Mitchell, & Goldin-Meadow, 2008), as are adults who gesture while learning sentences in a foreign language (Allen, 1995). Gesturing, like enactment, appears to be important in constructing new representations that will last over time, not only for new material that must be learned but, as we have shown here, also for familiar material.

Why does gesturing help recall? One possible explanation is that the motor coding involved in gesturing is particularly efficient for encoding information into memory and retrieving that information from memory. Glenberg (1997) has hypothesized that the function of memory is to support action. Consistent with this hypothesis, speakers show improvements in memory for enacted events even if they do not see their own movements during the enactment (Engelkamp, Zimmer, & Biegelmann, 1993), suggesting that is it the motoric code, rather than the visual code, that supports memory in the enactment paradigm. Moreover, recall for previously enacted events is impaired when motor distractors are present at test (Engelkamp & Zimmer, 1994; Saltz & Donnenwerth-Nolan, 1981), and activity is seen in motor cortex during retrieval of an event enacted during encoding (using PET, Nilsson et al., 2000; MEG, Masumoto et al., 2006; and fMRI, Russ, Mack, Grama, Lanfermann, & Knopf, 2003). Like enactment, gesturing may be particularly efficient for encoding information in memory, particularly in situations where motor codes may not be spontaneously invoked.

The data reported here suggest that gesturing can have an effect on memory whether or not the gestures are spontaneously produced (see Noice & Noice, 1999, 2001; Noice, Noice, & Kennedy, 2000, for evidence that movement has an impact on memory whether or not those movements are consciously planned). Participants who were instructed to gesture performed like participants who received no instructions but gestured spontaneously, and participants who were instructed *not* to gesture performed like participants who received no instructions and did not gesture spontaneously. This is consistent with recent evidence suggesting that instructed gesture can have the same cognitive benefits as spontaneous gesture with respect to both working memory (Cook & Goldin-Meadow, under review; Ping & Goldin-Meadow, 2010) and learning (Broaders, Cook, Mitchell, & Goldin-Meadow, 2007; Cook, Mitchell, & Goldin-Meadow, 2008; Goldin-Meadow, Cook & Mitchell, 2008). One reason may be that gesturing along with speech is a largely automatic process that, once engaged, seems to operate outside of conscious control. Although participants who are told to gesture are consciously using their hands as they describe each vignette, they are not likely to be aware of the particular movements they make (cf. Broaders et al, 2008).

One difference between our findings and those from enactment studies is performance on cued recall tasks. Previous studies have found that doing an action can improve memory for that action on a cued recall task (Kormi-Nouri, 1995). However, some studies have failed to find the effect (Steffens et al., 2006) and others have even found that verbal encoding is more effective than action encoding on cued recall (Engelkamp & Zimmer, 1997), similar to the effects we have found here. In our study, gesture was, if anything, associated with decreases in performance on an immediate cued recall test, although this effect was not sustained over time. One explanation for this finding may be that gesturing encourages speakers to generate their own internal visual representations of events, decreasing the usefulness of the actual visual representation as a recall cue. But differences in materials may also underlie the difference in performance. The cued recall test employed here contained only correct items, rather than the mixture of correct and lure items generally used in enactment studies.

One additional difference between our findings and studies of enactment is that doing an action has an immediate effect on memory, whereas gesturing appears to have an immediate and lasting effect on memory. Future work in an enactment paradigm using comparable memory tests will be necessary to determine whether enactment also affects long term free recall as gesture does.

As a final point of interest, recent work has found that describing an event in sign language (a type of enactment) leads to better recall than describing the same event in speech (von Essen & Nilsson, 2003; Zimmer & Engelkamp, 2003). This work has been interpreted to mean that sign language invokes some of the same types of motor representations as enactment (although, importantly, none of this work thus far has been conducted on native signers—it is therefore possible that at least some of the “signs” that the non-native signers in these studies produced really were enactments rather than linguistic representations). Our work raises the possibility that speech and gesture together function like sign language—that the motor representations invoked when using sign language may be comparable to those used when speaking *and* gesturing.

In sum, we have shown that gesturing, like enactment, can facilitate memory for events. Speakers who gesture when encoding information are more likely to remember that information than speakers who do not gesture. Adding gesture to speech thus makes speech more effective as a tool for remembering. Gesturing can thus turn speaking into doing, which, in turn, improves memory.

Appendix 1

Vignettes included in Study 1 and 2.

Dog moves to scooter

Taxi carries pig to barn

Chicken moves to sea captain

Man pushed garbage cart to motorcyclist

Motorcyclist moves to motorcycle

Baby crawls to chicken

Man bends over

Man carries chicken to scaffolding

Sea captain swings pail

Fence hits woman

Girl waves

Robot hands box to seacaptain

Basket slides to woman

Duck flies into wheelbarrow

Man picks up baby

Bike carries girl to giraffe

Woman pets dog

Girl gives a flower to a boy

Fence moves into position closing corral

Man throws ball into basket

Man plays guitar

Dog carries flower to doghouse

Train moves into fenced corral

Horse kicks seacaptian

Man pushed wheelbarrow to train

Bus moves to girl

Appendix 2

Actions included in Study 3 and 4.

Dust the hat

Stretch the elastic band

Shake the bottle

Look in the mirror

Turn on the flashlight

Blow the whistle

Pick up the battery

Toss the coin

Push the toy car

Buckle the belt

Stack the checkers

Roll the pencil

Open the book

Wind up the watch

Strike the match

Lock the bike chain

Draw the cup nearer

Flatten the plasticene

Throw the die

Squeeze the dog toy

Lift the stapler

Light the lighter

Fold the handkerchief

Flip over the magazine

Put on the glasses

Hang up the phone

Unroll the measuring tape

Bounce the ball

Close the purse

Smell the flower

Fasten the safety pin

Crumple the plastic bag

Break the toothpick

Read the Xmas card

Tear the paper

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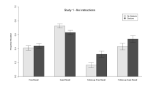

FIGURE 1.

Average performance on items in the four memory tests classified according to whether the participant spontaneously gestured when encoding the item. Bars represent standard errors.

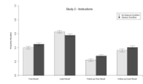

FIGURE 2.

Average performance on items in the four memory tests classified according to whether the participant was instructed to gesture when encoding the item. Bars represent standard errors.

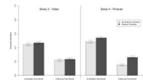

FIGURE 3.
Average performance on items in the two memory tests classified according to whether the participant was instructed to gesture when encoding the item. Participants who saw videos of actions are on the left; participants who saw pictures of actions are on the right. Bars represent standard errors.