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The effects of restricting hand gesture production on lexical retrieval and free recall.

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This study examined hand gesture production and the effects of restricting gestures on lexical retrieval and free recall. Participants were presented 50 definitions and attempted to retrieve each target word. Half the participants performed the task under restricted hand gesture conditions. Participants with unrestricted hand gestures retrieved and subsequently recalled significantly more words than participants whose hands were restricted. The role of hand gesture production in retrieval of verbal information from semantic memory is discussed. In addition, the lexical retrieval and recall data are analyzed as a function of high and low verbal skill and quantity and type of hand gesture production. The tip-of-the-tongue phenomenon is discussed in the context of gesture use and retrieval advantages.

Hand gesture production is common in human communication. There are several distinct types of hand gestures serving a number of different functions in speech production. Classifications of the more common hand gestures include iconic gestures (McNeill & Levy, 1982), metaphoric gestures (McNeill, 1985), and body-focused gestures (Freedman, O'Hanoln, Oltman, & Witkin, 1972; for a more complete classification see Ekman & Friesen, 1969, or Kendon, 1980). Iconic gestures are used to represent the imageable meaning of the verbal content of a word, as in opening a clenched fist to illustrate the word blossoming. Metaphoric gestures involve using a concrete gestural representation of an abstract word or phrase; for example, the phrase a direct limit might be accompanied by one finger moving horizontally across the speaker's center until halted in its path by the other hand (McNeill, 1985). Body-focused gestures, or motor movements, are forms of self-stimulation that are thought to focus a person's attention on a verbal task whenever there is interference with verbal production (Barroso, Freedman, & Grand, 1978).

It has been proposed that a primary function of gesture production is to assist with the communication of the semantic content of the message. For example, it has been demonstrated that recognition and recall of lists of sentences can be facilitated by accompanying the verbal event with an iconic gesture (Woodall & Folger, 1981). Similarly, Riseborough (1981) showed that there is better performance on tasks involving item identification, word list recall, and story comprehension for verbal materials that are accompanied by gestures (see also Berger & Popelka, 1971; Rogers, 1978). It has also been shown that gestures can aid viewers in the conceptualization of described visual designs (Graham & Argyle, 1975). Conversely, Krauss, Dushay, Chen, and Rauscher (1995) demonstrated that gesture viewing did not enhance accuracy of item recognition, thus questioning the assumption that gesture production is primarily for relaying information to the viewer.

Although the role of gestures in benefiting the recipient of the information is unclear, even less attention has been paid to the possible function that gestures might serve for the producer of the

message. Some evidence that gestures may serve some kind of function for the speaker derives from studies that manipulated whether recipients of messages could see the person talking. Presumably, if gestures serve solely a communicative function, then they should not be produced when the recipient of a message is not physically present. Cohen (1977; Cohen & Harrison, 1973), for example, required participants to give directions either face to face with listeners or via intercom. These studies found that the rate of gesture production was only slightly greater when participants communicated in person than indirectly, suggesting that an audience is not the decisive factor for gesture use.

One possible function that gestures may serve is as a cue to aid the speaker in lexical retrieval. For example, several studies have found that speakers are particularly likely to produce gestures when there is a breakdown in verbal retrieval (Butterworth & Beattie, 1976; Kendon, 1972; Riseborough, 1982; Werner & Kaplan, 1963). Similarly, Frick (1991) found that gesture production increased when the speaker was in a tip-of-the-tongue (TOT) state. When the speaker is unable to access the verbal target, the gesture in these cases may prime the lexical search by serving as an additional representation of the searched-for word, thereby cueing lexical access. Supporting this view, Krauss et al. (1995) hypothesized that gestures are the motoric conceptualization of speech. McNeill (1985) suggested that gesture and speech are at some point independent representations of ongoing thought processes. Furthermore, Fitts and Posner (1967) suggest that visual, motoric, and verbal representations can be accessed independently. Indeed, it has been demonstrated that gesture production may be semantically correct in some problem-solving tasks, even when the information cannot be expressed verbally (Church & Goldin-Meadow, 1986), and that in gesture-speech mismatches, gesture production is the precursor to comprehension and verbalization (Goldin-Meadow, Alibali, & Church, 1993). Similarly, McNeill (1985) found incidents of verbal and gestural mismatches where the gesture was semantically correct at output and the verbalization was only later corrected by the producer. Additionally, McNeill (1985) suggested that gestures display information that is supplementary to the speech content. According to Levelt (1989), gestures and speech are interdependent at a semantic planning stage, but are independent and ballistic at execution.

One possible reason that gestures might aid lexical access at times of verbal retrieval failure is that the gesture may be part of the memory representation of the lexical item, and retrieval of the motor component could serve as a mechanism for elaboration of lexical production. Butterworth and Hadar (1993, cited in Krauss, Chen, & Chawla, 1996) suggested that gestural enactment holds the conceptional activation in memory while the lexical search occurs. This is consistent with the position of Saltz and Donnenwerth-Nolan (1981) that during the act of processing a verbal event, motoric images are also activated as they represent one aspect of the word's semantic meaning. Similarly, Klatzky, Pellegrino, McCloskey, and Doherty (1989) suggested that mental representations of objects include a morotic component. Activation of the verbal representation also activates knowledge about its motoric component and how it is related to the function and structure of the object (Klatzky, McCloskey, Doherty, Pellegrino, & Smith, 1987). Conversely, it seems likely that activation of the motor component would also prime the verbal component, and thus may aid verbal production. Butterworth and Hadar (1989) propose that gestures enhance lexical retrieval by increasing the activation of the lexical target so as to lower the threshold for selection. In addition, gestural production may provide an imageable code that provides a supplementary route to retrieval of the verbal target. Similarly, Rauscher, Krauss, and Chen (1996) hypothesized that gestures facilitate verbal retrieval through cross-modality priming via activation of the semantic features of the lexical item.

An obvious way to test whether gestures aid verbal production would be to restrict hand movement during speech. Dobrogayev (1931, cited in Schlauch, 1936) reported that participants asked to communicate without the use of any motor movements produced labored speech, characterized by

decreased fluency, intonation, stress, and expression. Similarly, Graham and Heywood (1975) found that hand restriction resulted in increased time spent pausing during speaking, an increased number of hesitations, and an increase in the number of words used to describe spatial relationships (see also Rauscher et al., 1996, for similar results). Finally, Rime, Schiaratura, Hupet, and Ghysselinckx (1984) found that restricting hand movements resulted in decreased use of high-imagery words.

The present study was designed to examine further the function served by gestures during speech production by focusing on the speaker's retrieval of individual lexical items. Two experiments were conducted that examined verbal retrieval with and without restricted hand movement. It was hypothesized that if gesture production contributes to lexical retrieval by priming the speaker, then performance on lexical retrieval tasks should be better under unrestricted than restricted hand movement conditions. Similarly, if gesture production enhances retrieval performance because it provides supplementary information about the target word, then for the unrestricted group, meaningful gesture production should increase during incidences of retrieval difficulty such as when the subject experiences a TOT state. Additionally, if gestures function to enhance verbal retrieval, then target words with gesture accompaniment should be retrieved at a greater rate than words without gestures. However, if gestures serve purposes other than lexical retrieval (i.e., elaboration, conceptional "holding," and semantic activation), then gestural enactment may not necessarily result in enhanced retrieval in all cases.

The present study also examined gesture production as a function of general verbal skill. If gestures aid speakers when there is a breakdown in fluent speech production (i.e., during hesitations in speech production), then one might expect people with poorer verbal skills to use gestures more frequently than those with higher verbal proficiency. Supporting this view, Bernstein (1961) found that participants rated as having lower socioeconomic status (SES) substituted speech with gestures more often than did high-SES participants; one possible interpretation of this finding is that the lower-SES participants may have had poorer verbal skills and consequently relied more on gestures for communication. Dushay (1991, cited in Krauss et al., 1996) reasoned similarly by predicting that native English speakers would use more hand gestures when speaking a second language in which they were less verbally proficient than when speaking in their native language. However, he found that speakers used significantly more gestures while speaking English than when speaking their second language, suggesting a positive correlation between verbal skill and gesture use. In fact, Frick (1991) found that participants with higher verbal SAT scores used significantly more hand gestures while defining a target word than participants with lower verbal SAT scores and, more specifically, that high-SAT participants used more meaningful gestures for concrete word definitions than did low-SAT participants. Similarly, Hoffman (1968) found that participants with higher scores on written tests of verbal proficiency gestured more during performance of a verbal task than did participants whose scores were below average (see Baxter, Winters, & Hammer, 1968, for similar results). This suggests that participants with high SAT scores should use more hand gestures than participants with low SAT scores during tasks that require specific item retrieval.

EXPERIMENT 1

Experiment 1 examined the effects of restricting hand movements on lexical retrieval as a function of higher or lower verbal skills.

METHOD

Participants

The participants were 36 undergraduates (11 men and 25 women) who participated in the experiment to fulfill a course requirement.

Design

A 2 x 2 independent-groups design was used in the study. The independent variables were hand movement restriction (restricted [R] and unrestricted [U]) and SAT verbal scores (higher and lower). The primary dependent variable was the number of lexical items retrieved accurately following the presentation of word definitions. The lexical retrieval task was followed by a surprise free recall task testing memory for the defined words. Thus, the number of words recalled was an additional dependent variable. Hand movement restriction occurred during the lexical retrieval phase but not during final free recall. For the unrestricted group, additional dependent variables included the type and number of hand gestures used during lexical retrieval.

Materials

The 50 target words were all low-frequency English names of common objects and concepts (see Appendix). In order to maximize the likelihood of gesture use, items were selected that, in a pilot study, elicited a TOT state in 10% or more of the participants tested. The definitions of the words were modified from standard dictionary definitions (Webster's New Twentieth Century Dictionary, 1956), and the definitions were tape-recorded in a random order for stimulus presentation.

Procedure

A median split on the basis of verbal SAT scores was used to divide participants into higher (mean SAT = 541) and lower verbal skill (mean SAT = 420) groups. Half the participants at each level of verbal skill were randomly assigned to the restricted movement condition and half to the unrestricted condition. Participants were tested individually in sessions that lasted approximately 45 min.

Participants were told that the experiment was designed to study the TOT phenomenon, defined as "knowing you know a word that you are unable to generate." All participants indicated that they were familiar with the phenomenon. Participants were told that they would be given a list of definitions for which they were to try to produce the appropriate word, and that if they knew the word they should report it as quickly as possible. Participants were also told that if they did not know the word they should report that they did not know it, but if the definition elicited a TOT state they should take their time and continue to try to generate the word. Participants were also instructed to indicate to the experimenter when they experienced a TOT state, and that they could indicate a TOT state to the experimenter either during, or at the end of, the trial with that word. Participants were given a maximum of 1 min for lexical retrieval of each word.

Each session was videotaped for scoring purposes. Participants were required to depress a foot pedal during the testing session to ensure that they all adopted a standard standing position. They used one foot for half of the session and their other foot for the remainder of the session. To justify this requirement, participants were told that their scores were being compared with those of another group that had been required to tap the pedal at a certain rate. Participants in the restricted condition were further required to hold a rod with both hands in a comfortable position in front of their body during list presentation. This requirement prevented these participants from gesturing with their hands during the lexical retrieval phase of the experiment.

The tape-recorded definitions were presented in the same predetermined random order to each subject.

After participants attempted to provide the word for each definition, the correct word was given (either at the end of 1 min or when participants reported that they could not retrieve it). After the lexical retrieval phase, there was a 2-min interval during which participants were engaged by the experimenter in conversation, followed by a surprise 5-min written free recall test for the defined words. Participants were instructed to recall the words in any order and to try to recall all words, regardless of whether they had been able to retrieve a particular word themselves. Participants in the restricted movement condition did not have their hand movements restricted during the free recall task.

RESULTS

Lexical retrieval scores, gesture use scores, and recall scores were calculated for each subject. An alpha level of .05 was used for all statistical tests. Lexical retrieval scores consisted of the number of words generated correctly in response to the word definitions. Table 1 presents the lexical retrieval scores as a function of SAT and hand restriction. An ANOVA revealed that participants retrieved significantly more words in condition U than condition R, F(1, 32) = 4.98, p [less than] .05, and that higher SAT participants retrieved more words than did lower SAT participants, F(1, 32) = 6.31, p [less than] .05. The interaction between hand movement restriction and SAT was not significant, F [less than] 1.

Table 1. Mean number of words retrieved as a function of verbal SAT and hand restriction condition

	SAT			
	Higher		Lower	
Condition	M	SD	M	SD
Unrestricted	25.7	7.6	21.4	5.7
Restricted	21.7	4.5	15.7	5.3
Control (RG2)	23.7	5.4	13.8	6.1

Participants reported being in a TOT state for 12% of the items. Usually, when participants reported a TOT state, they were not able to retrieve the word within the 1-min time limit; overall, participants retrieved just 2% of TOT words.

Table 2 presents the free recall scores as a function of SAT and hand restriction. An ANOVA revealed that participants recalled significantly more words in condition U than condition R, F(1, 32) = 25.04, p [less than] .01, and that higher SAT participants recalled significantly more words than did lower SAT participants, F(1, 32) = 5.81, p [less than] .05. There was no significant interaction between hand restriction and SAT, F [less than] 1. Participants in the unrestricted hand movement condition recalled more of the words whose definitions had elicited a gesture (42%) than words whose definitions did not elicit a gesture (34%), but this difference was not significant.

Because the group and SAT differences in final recall may simply have been a reflection of group differences in the number of words retrieved during the initial phase of the experiment, an analysis was performed on the percentage of words recalled by each subject for three categories of items: correctly retrieved (non-TOT items), missed (non-TOT items), and TOT items [ILLUSTRATION FOR FIGURE 1 OMITTED]. This analysis revealed a significant effect of retrieval category, F(2, 63) = 3.67, p [less than] .05; participants recalled fewer missed items than words from either the TOT or correctly retrieved categories. In addition, there was a significant effect of hand restriction, F(1, 63) = 12.11, p [less than] .01, but the effect of SAT was not significant in this analysis, F(1, 63) = 2.09, p [greater than] .10. The interaction between hand movement restriction and SAT was not significant, F

[less than] 1. Thus, there was a significant impact of hand movement restriction on final free recall, even when group differences in initial lexical retrieval were taken into account.

Table 2. Mean number of words recalled on the final recall test as a function of verbal SAT and hand restriction condition

	SAT			
	Higher		Lower	
Condition	M	SD	M	SD
Unrestricted	18.9	3.9	14.8	4.6
Restricted	12.1	2.9	9.8	2.7
Control (RG2)	11.6	3.6	7.3	2.2

Tests revealed that there were no significant differences as a function of hand restriction in either the number of TOT occurrences during the retrieval phase, t(34) = 1.13, p [greater than] .05, TOT recall, t (34) = 1.51, p [greater than] .05, or conditional probability of the number of TOT words recalled out of the number of TOT retrieved, t(34) = 1.43, p [greater than] .05. Similarly, there were no significant differences between high and low SAT on TOT retrieval, recall, or ratio of recall to retrieval (p [greater than] .05).

In order to examine gesture production and its effects in more detail, gesture production during lexical retrieval (by participants in the unrestricted movement condition) was classified for each word into one of four categories: no gesture, iconic gesture, vague gesture, or motor movement. All hand movements that occurred during presentation of the definition or during lexical retrieval phase were considered gestures. Two types of gestures produced were scored as iconic: action gestures that depicted the functional aspect of the word or played out the imageable aspect of the word (e.g., making a diving motion with the arm to demonstrate the word kamikaze), or attribute gestures using the hands or fingers to outline the object's shape in the air (e.g., drawing a square to illustrate the word kiln). The motor movement category included all body-focused movements, such as stroking, finger or hand tapping, rubbing, and brief body touching (see Freedman & Steingart, 1975). Any other type of hand movements were classified as vague gestures, including metaphoric gestures, beats, and strokes. Metaphoric gestures were included in the category of vague gestures because they are abstract rather than direct representations of the word and hence were not thought to have the potential to be a good representation or retrieval cue, and also because metaphoric gestures could not be distinguished reliably from the other types of vague gestures. A second rarer classified gesture use on 250 of the trials, and the interrarer reliability for judgments of the four categories of gesture use was high (r = .94).

Table 3 presents the pattern of gesture production for higher and lower SAT participants as a function of whether the lexical item was identified as correct, missed, or TOT during retrieval. There were no significant differences in total gesture use (the sum of iconic, vague, and motor movement gestures) between higher SAT and lower SAT participants. However, high-SAT participants used significantly more motor movements than participants in the low-SAT group, t(16) = 2.83, p [less than] .01, and high-SAT participants recalled 52% more words associated with motor movements than low-SAT participants, but this was not significant, with t(16) = 1.89, p [less than] .08. It may be seen in Table 3 that the probability of gesture production was highest on TOT trials; gestures of some kind were produced on 82% (76/93) of TOT trials but on only 16% (62/389) of non-TOT missed trials and 9% (36/418) of correct trials. In addition, the conditional probability that a gesture was an iconic gesture was also greatest on TOT trials; 61% (46/76) of the gestures produced on TOT trials were iconic gestures, compared with 39% (14/36) of the gestures produced on correct trials and 31% (19/62) of the gestures produced on non-TOT missed trials. In fact, both high- and low-SAT participants

produced iconic gestures on TOT trials significantly more often than vague gestures, t(17) = 3.49, p [less than] .05, motor movements, t(17) = 2.25, p [less than] .05, and even no gesture use, t(17) = 2.42, p [less than] .05.

Table 3. Conditional probability of number of words recalled out of the words retrieved that were non-TOT correct, non-TOT missed, and TOT words as a function of gesture type and SAT in Experiment 1

Type of gesture					
Retrieval category	MM	VG	IG	Total	No gesture
Higher SAT					
Words correct (227)	10	5	8	23	204
Words missed (172)	21	6	5	32	140
TOT words (51)	10	8	26	44	7
Total	31	19	39	99	351
Lower SAT					
Words correct (191)	3	4	6	13	178
Words missed (217)	9	7	14	30	187
TOT words (42)	5	7	20	32	10
Total	17	18	40	75	375

Note. MM = motor movements, VG = vague gestures, IG = iconic gestures, TOT = tip of the tongue.

Table 3 also reveals that the high-SAT group had a greater frequency of motor movements for retrieval than the low-SAT group, but this difference was not significant, p [greater than] .05. Similarly, an analysis of the conditional probability of the number of words recalled given that were classified as motor movement words revealed that the high-SAT group recalled 63% of the motor movement words and the low-SAT group recalled only 11%, but this finding was not significant, t(16) = 1.89, p = .08. However, further analysis showed that only in the retrieval category of wrong answer did the low-SAT participants recall any of the motor movement words (33%), leaving the correct and TOT retrieval category recall at 0%. In contrast, the high-SAT group consistently recalled approximately 63% across all three categories; thus, a t test revealed significant differences between the high- and low-SAT groups on recall of motor movement words, t(16) = 2.83, p [less than] .01.

Overall, participants were not more likely to immediately retrieve an item correctly on trials when a gesture was produced than on trials when a gesture was not produced; overall, the conditional probability of correct retrieval given gesture production was 21%, whereas the probability of correct retrieval on trials when no gestnre was produced was 53%. However, this finding may be biased by the fact that many of the correct retrievals occurred very quickly after the presentation of the definition, before there was sufficient time for a gesture to be produced. Accordingly, a second analysis was performed examining retrieval as a function of gesture production, but for this analysis we eliminated from consideration all trials on which a word response was generated within 2 s of the presentation of the definition. It was found that even when these trials were not considered, participants still were not more likely to retrieve an item correctly on a trial when a gesture was produced (19 correct retrievals) than on a trial when no gesture was produced (23 correct retrievals).

DISCUSSION

Participants whose hand movements were restricted retrieved fewer words in response to word definitions than did participants who were free to produce hand gestures. This finding suggests that gestures may do more than facilitate message comprehension; gesture production may serve an important function for the speaker as well as for the listener.

We hypothesized that participants may produce gestures in the absence of an audience because gesture production aids lexical retrieval during speech, perhaps by serving as a motoric retrieval cue for word access. This view is consistent with the lexical facilitation hypothesis recently proposed by Krauss et al. (1996) in which they argued that motorically represented features may aid in the process of retrieval by serving as a cross-modal prime. One problem for this hypothesis is that, if gestures aid lexical retrieval by serving as a cue for the speaker, then one would anticipate an effect of hand restriction only when participants in the unrestricted condition actually produced a gesture before lexical retrieval. However, most of the words that were correctly retrieved were retrieved rapidly (80% of correct retrievals occurred within 2 s of the completion of the definition), whereas 90% of instances of gesture production occurred after the first 2 s following presentation of the definitions. In addition, participants were not more likely to retrieve an item correctly on trials when a gesture was produced than when a gesture was not produced, even when trials on which participants retrieved an item rapidly were eliminated from consideration. Indeed, gestures in general, and iconic gestures in particular, were most likely to be produced on TOT trials, but the frequency of correct retrieval on TOT trials was only 2% (see Read & Bruce, 1982). On the final free recall test for all presented words, it was found that participants in the unrestricted movement condition recalled more words than did participants in the restricted condition, even though the hand restriction manipulation did not extend to the recall phase of the experiment. Part of this effect may have been due to group differences in the number of words retrieved in response to the dictionary definitions; research on generation effects (Anderson, Goldberg, & Hidde, 1971; Slamecka, & Fevreiski, 1983; Slamecka & Graf, 1978) has shown that self-generated items are better recalled than items provided by the experimenter. However, differences in recall between the groups remained even after group differences in initial word retrieval were taken into account. It has been found that overt actions may facilitate the retention of related verbal materials (Backman, Nilsson, & Chalom, 1986; Saltz & Donnenwerth-Nolan, 1981). In the present study, however, there was little evidence that gesture production per se enhanced verbal recall; instead, the recall advantage for participants in the unrestricted movement condition was as large for correctly retrieved items (for which gesture production was infrequent) as it was for TOT items (which typically elicited a gesture). Thus, if participants in the unrestricted movement condition engaged in more elaborate processing of the target items or the definitions, the difference was not restricted to items that elicited an overt gesture.

The present experiment also tested for verbal skill differences in gesture use. Past research bas painted an inconsistent picture of gesture use as a function of general verbal skills. In the present study, no significant differences were found between higher and lower verbal SAT score groups in terms of the total number of gestures produced or the numbet of vague or iconic gestures produced (see Table 3). The one difference found in gesture use as a function of verbal skill involved motor movements; participants with higher verbal SAT scores used more motor movements than did participants with lower SAT scores across all retrieval categories (correct retrievals, TOT-state items, and non-TOT incorrect trials). These gestures are thought to serve as a tension-regulating or attention-focusing mechanism (Barroso et al., 1978; Freedman et al., 1972; Freedman & Steingatt, 1975; Mahl, 1968). However, the exact advantage for the higher SAT groups awaits further experimentation.

One hypothesis that may account for the effects of hand restriction on both initial lexical retrieval and later recall is that restricted movement participants may have had to allocate some of their limited attentional capacity to the task of maintaining their hands on the bar. Essentially, this hypothesis

proposes that participants in the restricted condition were presented with a divided attention task during the initial phase of the experiment; one task required them to access lexical items in response to definitions, and the other task required them to maintain their hands on the bar, with both tasks presumably requiring the allocation of attention. This division of attention would be expected to result in poorer performance on the lexical retrieval task itself, and would also be expected to reduce the elaborateness of the encoding of the definitions and lexical items, thereby reduciug later free recall performance. However, several studies report that the experience of a TOT results in agitation (Brown & McNeill, 1966; Wellman, 1977) and emotional reactivity (Gruneberg, Smith, & Winfrow, 1973), or TOTs are caused by distraction and demand fully conscious and effortful attention to resolve (Reason & Mycielska, 1982). Following this reasoning, if participants in the restricted group were being distracted by the bar they were holding, then they should have experienced more TOTs than the unrestricted group. In the present study there were no significant differences between the unrestricted and restricted groups in the number of TOT experiences or the number of TOT words recalled.

One way of testing whether the effects of hand restriction on lexical retrieval and recall are robust and not due to a divided attention effect is to restrain hand gestnres in such a manner that participants do not have to concentrate on hand restriction. If the debilitating effects on restricted participants in the first experiment are due to participants' allocating capacity to hand restriction, and not the prevention of motor execution, then participants whose hands are bound in a normal and comfortable position should perform as well as the unrestricted participants in the first experiment. However, if the poorer performance of participants in the hand restriction condition is due to the inability to gesture, then participants whose hands are comfortably bound should perform in a similar manner to the restricted hand participants in Experiment 1. Experiment 2 was designed to test this prediction.

EXPERIMENT 2

Experiment 2 was designed as a control to determine whether the differences found in performance between the restricted and unrestricted groups in Experiment 1 are robust if participants do not have to purposefully hold an object in order to prevent hand gestures. There was no unrestricted condition in Experiment 2. Participants in Experiment 2 were tested in exactly the same way as the restricted participants in Experiment 1 except that they were required to wear an apron with pockets that prevented hand use during word retrieval.

METHOD

Participants

The participants were 18 different undergraduates (4 men, 14 women) who participated as part of a course requirement.

Apparatus

An apron with two deep pockets on each side held the participants' hands in a natnral position. The apron was tied around each subject so that the apron's pockets were adjusted for each subject's arm length. Once the subject was comfortable, velcro restraining ties also were fastened at the top of each pocket to prevent the subject from moving his or her hands.

RESULTS

Tables 1 and 2 reveal that participants in Experiment 2 (restricted group 2 [control RG2]) demonstrated the same pattern of retrieval and recall as did participants in the restricted group in Experiment 1. An ANOVA showed no significant differences in any analyses between participants in the hand restricted condition in Experiment 1 and participants in Experiment 2.

DISCUSSION

The primary finding of this experiment is that the differences found between the participants in Experiment 1 whose hand movements were restricted and participants whose hands were free to move is robust. Because participants did not have to concentrate on not moving their hands, it seems likely that the divided attention task can be ruled out as a possible reason for the poorer retrieval of participants with restricted hands. This seems to indicate that it is the inability to gesture that reduces lexical retrieval and recall, perhaps due to a less elaborative processing of the material.

GENERAL DISCUSSION

The present study examined gesture use, and the effects of restricting participants' hand movements, during retrieval of information on recall of the verbal material. The primary finding from the study was that participants whose hand movements were restricted retrieved fewer lexical items in response to word definitions than did participants whose hand movements were not restricted. One possible explanation for the hand restriction effect is that participants in the restricted movement condition had fewer cognitive resources available for lexical retrieval than did participants in the unrestricted condition. In a sense, participants in the restricted hand movement condition were presented with a divided attention task; one task required them to access lexical items in response to definitions, whereas the other task required them to maintain their hands on the bar. If the latter task required the allocation of attentional resources, then it would be expected to hinder performance on the primary lexical retrieval task. Moreover, to the extent that division of attention resnlted in a reduction in the elaborateness of the encoding of the definitions and lexical items, a detrimental effect on final free recall performance might be expected as well.

The results in Experiment 2, in which participants in the hand restricted group performed similarly to restricted participants in Experiment 1, seem inconsistent with this attentional explanation. Craik (1983) demonstrated that division of attention adversely affects retrieval of information from episodic memory. Thus, if the attentional division explanation for the Experiment 1 findings is correct, one would anticipate that the hand restriction group of Experiment 2 would perform more like the unrestricted group in Experiment 1. However, the findings did not support this prediction.

An alternative class of explanations for the hand restriction effect focuses on the role of hand gestures as facilitators of lexical retrieval. That is, gestures may serve as retrieval cues for items whose verbal labels are not immediately accessible (Krauss et al., 1996; Frick, 1991). For example, when the verbal system is unable to retrieve a word, a morotic representation of a searched-for word could act as a pictorial illustration of the item. Gesture production could also result in the activation of information that was not present in the first activation (e.g., associations, elaborations, inferences), or might help guard against the activation of competing information that would interfere with the retrieval process.

As noted previously, however, one problem for gestures-as-retrievalcues explanations for the hand restriction effect is that overt gesture production was not directly associated with an increased likelihood of item retrieval. That is, for participants in the unrestricted movement condition, the conditional probability of item retrieval given gesture production was not greater than the conditional probability of item retrieval in the absence of gesture production. Of course, evidence for a direct

effect of gesture production on retrieval might have been found if participants had been given longer to try to retrieve each item. It should be noted, however, that the 1-min time limit for item retrieval provided here was not at all brief by the standards of lexical retrieval research. Moreover, we did find an overall effect of hand movement restriction; it is just that the effect was not limited to cases in which participants actually produced a hand gesture before lexical retrieval.

It is possible that a focus on overt gesture production is the wrong place to look for an explanation for the hand restriction effect. Instead, the role of gestures in lexical retrieval may occur at the stage of motoric anticipation, which could occur as part of the normal retrieval process but before overt gesture production. Presumably, the rod-holding activity could have inhibited this anticipatory gesturing, thereby hindering lexical retrieval. One reason that gestures might function in this way to aid retrieval is that the morotic representation may become related to the lexical representation during word acquisition (Werner & Kaplan, 1963). Supporting this view is evidence that the development ofmotoric representations precedes verbal production Acredolo & Goodwyn, 1985; Church & Goldin-Meadow, 1986; Goldin-Meadow et al., 1993) and concept formation (Piaget, 1936, 1952). It has been shown that, even for adults, motoric patterns related to object functions may become part of the representations of objects (Klatzky et al., 1987, 1989). The present findings suggest that the activation of motor representations may enhance retrieval of corresponding lexical representations. Further research is required to specify the mechanism by which the enhancement occurs.

Appendix: Word definitions for Experiments 1 and 2

Mannequin: a lifelike model of a human figure used to display clothing in a shop window.

Hieroglyphics: a picture script of the ancient Egyptian people usually carved on the stones in pyramids.

Guillotine: an ancient machine used for beheading by means of a heavy blade.

Skewer: a piece of thin metal used to pierce and cook a beef kabob over an open fire.

Kaleidoscope: an instrument containing loose bits of colored glass that produce an ever-changing pattern when the position is revolved.

Lasso: a long rope with a running noose that is used of roping cows and borses.

Chaps: leather leggings resembling trousers without a seat that are usually worn by cowboys.

Buoy: a floating object moored to the bottom of a body of water to mark a channel.

Loupe: a small magnifying eyepiece used by,jewelers and watchmakers.

Kamikaze: a Japanese air attack corps assigned to make suicidal crashes on a target.

Wicket: an arch or hoop in croquet that the balls have to be hit through.

Horizontal: a word used for a position of an object that is parallel to the plane of the ground.

Machete: a large, heavy knife used for cutting a path through the jungle.

Javelin: a slender shaft of wood tipped with iron and thrown for distance in an athletic field event.

Ukulele: a very small guitar with four strings popularized by Hawaiian musicians.

Trellis: a frame of latticework for climbing plants in a yard.

Skylight: an opening in a house roof to admit snnshine.

Palette: a thin oval tablet with a hole for the thumb at one end by which a painter holds it and mixes different shades of pigment on it.

Silhouette: a black cutout of paper to represent the outlines of a person's head.

Gargoyle: a carved grotesque human or animal figure projecting from the roof of a building, typical of older structures, especially castles.

Castanets: a small rhythm instrument used especially by dancers, consisting of two small shells that are clicked together by the fingers.

Metronome: a pendulum-like instrument designed to mark exact time by a regular ticking such as 2/4 time for a piano score.

Atomizer: the name of a type of perfume container which typically sprays a fine mist when the air bulb is squeezed.

Bellows: a tool-like object with accordion pleats that blows air out of one end and is used to intensify a fire.

Banister: a handrail usually going down a staircase, made of smooth, rounded wood with perpendicular supports adjoining to the stairs.

Tambourine: a one-sided drum with loose metallic disks in the sides that is played by shaking.

Chandelier: a large ornate lighting fixture hanging from the ceiling.

Monocle: an eyeglass for one eye held in place by the lower eye socket and upper eye lid.

Tuning fork: a two-pronged, metal instrumeut that gives a fixed, pure tone when struck.

Abacus: an ancient instrument for performing calculations by sliding disks along a series of straight rods.

Bleachers: uncovered stand of progressively higher rows of wooden planks for spectators to sit on.

Curtsy: an action showing respect to royalty usually done by women where they bow slightly and bend at the knee.

Escargot: garden snails eaten as an appetizer.

Filament: a flexible threadlike incandescent object inside a light bulb.

Washboard: a corrugated rectangular surface women used to use to scrub clothes with.

Gondola: a long, narrow flat-bottomed boat used on the canals of Venice.

Matador: the name used for a person that fights bulls.

Ignana: the name of a large lizard with a serrated dorsal crest, found in the tropical regions of South America.

Rheostat: a type of light switch that dims or brightens a lighting fixture.

Shamrock: a clover-like plant typically used as a symbolic emblem by the Irish and thought to be good luck.

Harpoon: a large barbed spear used for htmting whale or other large fish.

Labvyrinth: a large maze usually defined by tall shrubberv.

Kiln: a large oven used to fire clay or ceramic pottery.

Urn: a type of vase used to put the cremated remains of a person.

Eclair: a type of pastry with a cream-filled center and covered with chocolate.

Scarab: an Egyptian stone ornament in tile shape of a beetle.

Syringe: a needle device used to give an injection to a person.

Bassinet: a type of cradle used for infants, made of wicker with a hood over one end.

Gyroscope: a toy or instrument used to illustrate the earth's rotatitm by balancing and spinning rapidly about an axis.

Note

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