

The Effectiveness of Four Mnemonics in Ordering Recall

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Four groups of subjects were given instructions in using one of four mnemonic techniques: imagery, the link method, a peg system, or the method of loci. Relative to a control group, all mnemonic groups showed an advantage in memorizing 20-word lists for unordered recall. However, the greatest differences appeared when recall was scored by a strict positional criterion whereby subjects received credit for recalling a word only when it was placed in its correct position. By this scoring method, peg and loci subjects performed best on an immediate test, and imagery and control subjects, worst. Performance of subjects told to use linking images was intermediate. Mnemonic devices have greater effects on the ordering of recall than on the number of words that can be recalled without regard to order. Some experimental failures to show that mnemonic devices are effective may have been due to testing only item information.

Since the time of the ancient Greeks, a great variety of mnemonic systems have been developed for aiding recall when it is not possible to provide oneself with external retrieval cues (Yates, 1966). There have been several studies to test the effectiveness of the systems relative to the strategies subjects normally adopt when faced with a memorization task. Although there are verbal mnemonic systems, most memory aids rely on some form of imagery instruction to subjects, who are encouraged to represent the to-be-remembered material in terms of mental images. The simple advice to use images can serve as a powerful mnemonic. For example, Bower (1972) showed that paired associate recall of lists of concrete nouns was much better when subjects were instructed to form interactive images of the referents of the nouns at study than when they were instructed simply to rehearse the pairs. It seems important that the images formed be interacting with one another to aid recall, but the popular notion that the

images should be bizarre does not seem accurate (Wollen, Weber, & Lowry, 1972; Wood, 1967).

There are several simple mnemonic systems involving imagery that can be used for remembering many different sorts of information. Perhaps the simplest is the link method (Lorayne & Lucas, 1974). When using this technique people are told to take the items they want to remember (whether they be objects on a grocery list, points in a speech, words on a list, etc.) and convert each item into an imaginal representation. The point of the technique is to link each successive pair of items in an interacting image so that recall of one item in the list should cue recall of the next. Thus, ideally, one would have an associate chain of interacting images that could support recall of the items in their appropriate order. The advantage of this method is that it is quite simple to learn; there is no necessary scheme or set of materials to learn in advance as in the other techniques. The link method should be better than a simple imagery instruction when people are required to recall information in order, but ordered recall may not be optimal, because if people forget one item in the list, recall for the others (or at least their appropriate order) may be disrupted. Morris and

The author would like to thank Deborah Griffith, Mary Rymers, and Stephen Schmidt for their aid in conducting this research.

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Stevens (1974) have shown that instructing subjects to link the images of words together improved their free recall of words relative to subjects told to form images of each word. In fact, the latter subjects performed no better than uninstructed control subjects, suggesting that imagery instructions only lead to improved free recall if they lead subjects to form interactive or linking images.

The mnemonic techniques that have been most often investigated are the method of loci and the peg method. In the method of loci, one takes a well-learned series of locations, such as a path one travels daily, and in learning a series of items converts each item into an image and deposits the image at some salient location along the path. It is customary to advise a person to mentally walk the path while learning the series and to imagine the to-be-remembered items at prominent locations along the way. When the series is to be recalled, one should again imaginably traverse the path, "looking" at each location and calling out the name of the item deposited there. The method of loci should provide for better ordered recall of objects relative to the link method, since forgetting of one item should not disrupt recall of others.

The third popular type of imagery mnemonic is referred to as the peg or hook system, and is based on principles similar to those embodied in the method of loci. The main difference is that instead of a series of places to be used as storage "locations," one memorizes a set of pegs or hooks on which one can then "hang" the information to be memorized. There are a variety of particular peg or hook systems that can be used (see Paivio, 1971, chapter 6), but one of the most popular, and the one investigated in the present research, is a system of rhyming pegs ("one is a gun, two is a shoe, three is a tree," etc.) that one must memorize. Once the rhyme mnemonic has been learned, one can use it to remember a series of items in order by forming an image of the first item and making it interact with a gun, the first peg word. An image of the second item is constructed with it interacting with a shoe, and so on. Each of the pegs or hooks allows one to hang on it a to-be-recalled item. At recall

one has a good system of retrieval cues; the numbers from 1 to 20 are not in danger of being forgotten, and if the rhyme system is well learned, one can generate the cues for the to-be-remembered items. The cues are effective because they have been linked to the target items by interactive images.

Although there are ringing personal testimonials to the effectiveness of these techniques in improving recall, the empirical literature on their effectiveness relative to appropriate control groups is often surprisingly unimpressive. For example, Smith and Noble (1965) investigated a peg or hook memory system in which, following an hour lecture on the method and 4 days of practice using it, subjects were asked to memorize lists of 10 consonant-vowel-consonant (CVC) trigrams that varied in meaningfulness. Control subjects were not trained on any special technique and were asked not to use any special system in learning. Subjects received 20 trials of serial anticipation learning on the 10-item lists. Smith and Noble (1965) found that the peg mnemonic aided learning of medium and low meaningfulness trigrams but did not affect learning of the highly meaningful trigrams. They concluded that the mnemonic had "no efficacy for remembering highly meaningful materials under the present conditions" (p. 123).

Other studies have found the peg system to be effective (Bugelski, Kidd, & Segmen, 1968; Senter & Hauser, 1968; Wood, 1967), although in some cases the advantage relative to the control condition was not particularly impressive. Bugelski et al. (1968) varied presentation rate and found that subjects using the peg system performed better than controls only at the slower presentation rates (4 and 8 sec per item). At rapid rates of presentation, subjects presumably do not have time to indulge in the encoding gymnastics necessary for success with the mnemonic.

There have been fewer investigations for the method of loci and the link method. As already mentioned, Morris and Stevens (1974) showed that instructions for subjects to link images together improved free recall relative to control groups that were told to form images or were given no instructions.

However, they did not investigate the explicit link method as advocated by Lorayne and Lucas (1974), among others. Occasionally, studies of the method of loci (e.g., Ross & Lawrence, 1968) have produced suggestive evidence for the effectiveness of the method, but the cited study was marred by the lack of appropriate control conditions. However, there seems little doubt that the feats of people well trained in the method are quite impressive (e.g., Bower, 1970; Groninger, 1971; Luria, 1968).

There are few studies that have attempted to compare the effectiveness of different mnemonic techniques. Bower and Winzenz (1970) found that interactive imagery instructions produced better retention of paired-associate lists than did instructions to generate a sentence from the word pairs, to read the words in a sentence, or to repeat the words. Recall in the other three conditions was ordered as listed. The instruction to generate sentences produced recall that was almost as high as that in the interactive imagery condition. Foth (1973) compared recall of 10 paired associates under five different instructional conditions. Besides an uninstructed control, there were two groups that were instructed in the number-rhyming peg system, but with instructions to use either imaginal mediators or verbal mediators for the to-be-remembered pairs. A fourth group was taught a different peg system and told to use imaginal mediators, and the fifth group was taught a method of loci technique by which they were to imagine the referents of to-be-remembered words on the parts of an automobile. The stimuli were the numbers 1-10, and the responses were either concrete or abstract nouns. Foth (1973) found no advantage of the mnemonic systems on recall of abstract nouns, but all of the mnemonic conditions except the loci method produced a reliable advantage to the control group with concrete nouns. The advantage of the mnemonic groups was only on the order of two more words (or slightly less) recalled than the control condition. There was no difference between verbal and imaginal mediation conditions with either concrete or abstract nouns.

The purpose of the present experiment

was to compare four different mnemonic devices in aiding recall. However, unlike prior experiments, the method allowed separation of the effects of mnemonics in recall of items without regard to order and in their appropriate order. In previous studies subjects were tested in most cases on recall of items without regard to their order. It may be that the most common mnemonic devices, though aiding somewhat the number of items recalled, have their greatest effect in the recall of the order in which the items occurred. It might be expected that the peg and loci methods provide best ordered recall, with the link method being somewhat less effective, since forgetting of one link in the associative chain may disrupt order of recall of other items. In the present study relatively long lists (20 words) were used, and recall was not cued. Another possible reason that previous studies have found little or no effect of mnemonics in aiding item recall is that with short lists and cued (paired-associate) recall, the control group performs so well there is little room for improvement. Subjects in the present experiment were given free position recall instructions (Crowder, 1969); they were told to recall the words in any order they wanted, but to try to place the words in the order they had occurred on the list. By this technique evidence can be gained as to whether mnemonic devices aid recall of the order of items even if they do not much improve the total number of items recalled.

There were five conditions in the present experiment. Four groups of subjects were given instructions in forming images, or in using the link, peg, or loci methods on the first night of the experiment. On the second night they studied and were tested on three lists of words, and on the third night they were tested again on the lists learned the previous night. The control condition was given elaborative rehearsal instructions; they were told to repeat the words to themselves and to think of their meanings while doing so. Such a control is more appropriate than a simple rehearsal condition in which subjects are instructed to repeat the words, since such a condition might actually produce worse recall than no instruction (e.g.,

Table 1
*Mean Numbers of Words Recalled by Subjects in the Different Conditions
 When Scored by a Lenient Criterion*

Condition	<i>n</i>	Practice list	Test list							
			Immediate recall				24-hr delayed recall			
			1	2	3	<i>M</i>	1	2	3	<i>M</i>
Rehearsal	32	13.2	10.8	11.6	11.7	11.4	5.1	6.1	7.6	6.3
Imagery	25	12.4	14.1	12.5	12.6	13.1	7.6	6.6	6.2	6.8
Link	31	13.0	14.4	15.8	16.6	15.6	9.3	11.3	13.0	11.2
Loci	29	12.6	14.0	16.0	15.9	15.3	9.2	11.7	11.1	10.6
Peg	33	13.1	13.2	14.7	14.6	14.2	7.2	8.4	9.1	8.2
<i>M</i>		12.9	13.3	14.1	14.3		7.7	8.8	9.4	

Glanzer & Meinzer, 1967). An uninstructed control group is also not desirable, since subjects' motivation may be affected by the belief that they are being taught an effective method of memorization (Paivio, 1971, p. 334). Thus the elaborative-rehearsal control seems a more appropriate control than is typically used in studies comparing the effectiveness of mnemonic techniques. The condition in which subjects were simply told to form mental images also serves as a useful control. Since it is well known that such instructions improve recall relative to an uninstructed control condition, it is of interest to ask whether the link, peg, and loci methods (which all involve imagery instructions) provide gains in recall above that provided by a simple imagery instruction.

Method

Design and Subjects

Subjects were tested in one of five conditions that differed in the instructions and training they received in the use of a particular memory strategy. The five conditions, as labeled by the mnemonic that subjects were supposed to use during study of the material, were imagery, link, loci, peg, and rehearsal. The subjects were 150 Purdue undergraduates who served in partial fulfillment of a course requirement. Different numbers of subjects served in each condition for the three sessions of the experiment (see Table 1), but at least 25 participated in each condition.

Materials

Eighty high-imagery words were selected from the Paivio, Yuille, and Madigan (1968) norms. All were concrete nouns with imagery values greater than 6.0.

The words were randomly assigned to four lists of 20 words. The position of the words within lists was also randomly determined.

Procedure

Most subjects participated in groups of 8–12, though some were tested in slightly smaller groups. When subjects signed up for the experiment they were informed that participation would require that they appear at the laboratory at the same time on three successive evenings. Twelve subjects were lost due to attrition; each group lost at least one and no more than three.

When subjects arrived in the lab on the first night, they were reminded that they would have to participate on all three nights in order to receive credit. Then they were told that their first task would be to study a series of 20 words that would appear on a screen and try to recall them in order as well as possible. They were told to try to remember each word and its position. They were given a recall sheet with the numbers 1–20 in a column and told that they would be asked to recall the first word beside the first number, the second word beside the second number, and so on, but that the words could be recalled in any order they wanted. Subjects were further instructed that if they remembered a word but were unsure of its position, they should write it down beside any number or put it at the bottom of the page. They were told that they would have 5 min to recall the words. After the experimenter answered any questions, the practice list words were shown at a 7-sec rate via a Kodak Carousel slide projector. Subjects were then given a 5-min recall test. The reason for testing subjects on the practice list was to familiarize them with the task and to determine if the groups were initially of equivalent ability. The practice list was randomly chosen from one of the four lists and was the same for all subjects.

After the recall sheets were collected, subjects were told that they would be taught a particularly effective technique for memorizing a list such as the one they had just seen. They were also told that they would be asked to use the technique to memorize more lists the next night. At this juncture subjects

were given detailed instructions about the specific mnemonic technique that they were to use in memorizing the lists. The details of each technique are briefly described below. Subjects were also given a sheet with the name and a brief description of the technique to study before the next night. They were asked to practice the technique on the practice list, which was provided on the back of the sheet.

The rehearsal method. Subjects were told that they should try to remember the words by saying each one over to themselves a number of times. The following instruction was also given to them and provided on their sheets:

However, you should not just repeat a word in a rote, automatic way, but try to think of the meaning of the word as you are repeating it to yourself. It may also help if you repeat a whole series in order. For example, after you have seen the first three or four words you might try to rehearse all of them together.

The mental image method. Subjects were told to "form very vivid mental images. Every time you see a word try to get a very clear image of it floating freely in space against a uniform background." They were told that the image should not be of the word itself, but of the object the word referred to, and that they should try to remember the order of the words. No suggestion was made on how to keep track of the order. All groups instructed to use a mnemonic device involving imagery were told to use large and unusual images in order to make the task more interesting and engaging.

The link method. In this condition subjects were told to link the image of each word with the image of its predecessor by having them interact, and to make the association or link between the two unusual or ridiculous. They were told to do this for each list word and that they might link the first word to a common object near them, such as the blackboard. Finally, they were instructed that when they attempted to recall the words, the image of one word should serve as a cue for the next and so on throughout the list. An example was provided of how the link method could have been used to memorize the first few words in the practice list.

The loci method. Subjects were told that they should think of a series of 20 familiar locations that could be ordered in some sensible way, for example, a familiar campus path or series of locations around their houses. They were instructed to imagine themselves walking by the locations and placing images in them while studying the list. They were to repeat this mental walk when tested, looking in each location and reading off the name of the object stored there. The experimenter provided an example of how the method of loci might have been used to remember the first few items in the practice list they had just seen. Subjects were told that they should work out the locations they were to use by the following night and practice the list given to them with those locations.

The peg method. Subjects were told that in order to improve their memories they must first learn a series

of "memory pegs." These were the mnemonic rhymes for the numbers 1-20 ("one is a gun, two is a shoe," etc.). The series was that used by Bower and Reitman (1972) with a few changes. Subjects were instructed to memorize the pegs overnight. They were told that these pegs would be useful in memorizing a list of words by forming an interactive image between the last word in the rhyme and the word they were trying to remember. They were told that if they did this with all 20 words in the list, they should be able to recall them in order later on. "Since you will already know the peg words, at recall you only need to produce each peg word from the rhymes and see what other object is in the image with the peg word object." The experimenter provided an example of how the peg system could have been used to memorize the first few words in the practice list.

After the method by which subjects were to memorize the list was carefully explained and subjects' questions were answered, they were again encouraged to practice the system on the list they were given before the next session and reminded of the time of the session. Subjects taught the loci and peg systems were also told that they would be expected to write out the locations or pegs the next night.

When subjects reported for the second session, they were told that they would be asked to memorize and recall three lists of words. They were first reminded of the critical elements of the mnemonic system they were to use, and peg and loci subjects were required to write down their 20 peg words or loci. A few subjects in these conditions had some difficulty with this requirement. For all peg subjects the experimenter read the rhyming list once again. The loci subjects were given a few additional minutes to make sure that they knew the set of locations well. When all claimed to be ready, the first list was presented.

The procedure for presentation and recall of the three lists was the same as for the practice lists. Subjects were given free position recall instructions, the words were presented at a 7-sec rate, and the recall test lasted 5 min. There was an approximate 2-min interval between recall of one list and presentation of the next during which subjects' recall sheets were collected and new ones were distributed. Each recall sheet had the numbers 1-20 listed in a column with a space beside each number. At the end of the session, subjects were told that during the next session they would be tested by the same method on other lists. This was to prevent the suspicion that they would be asked to recall the same lists again.

During the third session subjects were given a recall sheet with three columns of 20 spaces and the numbers 1-20 beside the spaces. Above the first column was the label List 1, with similar appropriate labels above the other columns. Subjects were instructed that their task was to attempt to recall as many words as possible from the lists seen the previous night. They were told to try to assign a recalled item to the correct list and position, but to write it in anywhere if they were not certain. Subjects were given 15 min for this task and were encouraged to keep trying throughout the entire period, even when they thought they had recalled all the words they could.

Table 2
 Mean Numbers of Words Recalled by Subjects in the Different Conditions
 When Scored by a Strict Positional Criterion

Condition	n	Practice list	Test list							
			Immediate recall				24-hr delayed recall			
			1	2	3	M	1	2	3	M
Rehearsal	32	7.0	5.5	6.2	5.8	5.8	1.0	.9	2.1	1.3
Imagery	25	6.8	4.3	5.0	5.3	4.8	1.2	.8	1.2	1.0
Link	31	7.6	8.2	9.3	11.4	9.6	4.2	4.4	6.5	5.0
Loci	29	6.8	11.9	14.4	14.4	13.6	5.2	6.0	6.0	5.8
Peg	33	7.7	11.1	13.2	13.2	12.5	4.3	4.8	5.5	4.9
M		7.2	8.3	9.8	10.1		3.2	3.4	4.3	

Results

Practice Lists

Subjects' performance on practice lists can be used to ascertain the comparability of subjects' abilities in the different conditions, since all groups were treated identically through the study and recall of the practice lists. The practice list results were scored by both a strict criterion (subjects were given credit for recalling a word only if it was recalled next to the appropriate numbered position on the answer sheet) and a lenient criterion (subjects were given credit for recalling a word if it appeared anywhere on the sheet). The results are presented in Tables 1 and 2. With strict positional scoring, average recall varied from 6.8 to 7.7 on the practice list, whereas with lenient scoring, recall varied from 12.4 to 13.2. In neither case was there reliable variation among the groups, $F(4, 149) < 1$ in both cases, $MS_e = 14.36$ for strict scoring and 7.37 for lenient scoring. (A criterion of $p < .01$ was used for all statistical tests.) Thus the groups were comparable in ability to memorize a list prior to introduction of the mnemonic strategies.

Lenient Scoring

Presented in Table 1 are the mean numbers of words recalled by subjects in the five different conditions on the three lists and averaged across the three lists in both the immediate and 24-hr delayed recall tests when scored by a lenient (free recall) scoring criterion. Immediate recall was better for the conditions in which subjects were

taught specific mnemonic devices (link, loci, and peg conditions) than in the rehearsal control condition. An analysis of variance revealed a reliable effect of conditions, $F(4, 290) = 11.30$, $MS_e = 23.74$, and lists, $F(2, 290) = 8.63$, $MS_e = 4.97$. The interaction between conditions and lists was also reliable, $F(8, 290) = 4.24$, $MS_e = 4.97$, and appears to have been caused by the fact that recall in the imagery condition decreased slightly across lists, whereas recall in the other four conditions increased across lists. Multiple comparisons of the mean scores with Fisher's least significant difference (LSD) test indicated that all conditions involving an imagery instruction differed reliably from the rehearsal control condition. In addition, subjects' recall in the link and loci conditions differed reliably from that in the imagery condition, and recall in the peg condition differed from that in the link condition. No other differences were reliable.

The serial position curves in immediate recall for the five conditions are presented in Figure 1. The curves represent average recall of the three lists. Although the curves are rather irregular, recall in the rehearsal and imagery conditions is inferior at the interior serial positions. The poorer recall in the peg condition relative to that in the link and loci conditions is confined to Serial Positions 13-17.

The 24-hr delayed recall results with lenient scoring on the right side of Table 1 were generally similar to the immediate recall results. All the statistical conclusions drawn about immediate recall also apply

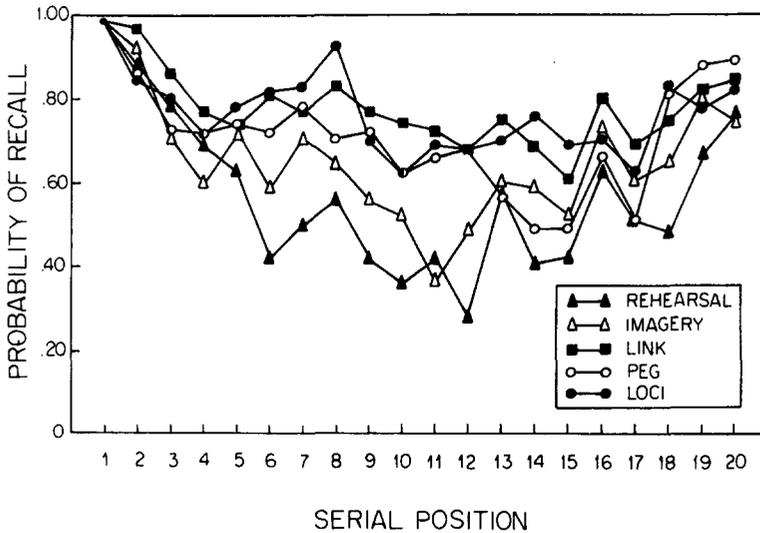


Figure 1. Serial position curves for the five conditions with lenient scoring when averaged over the three lists.

to delayed recall, except that the rehearsal and imagery conditions did not differ and the peg condition was reliably different from all others.

Strict Scoring

Presented in Table 2 are the mean numbers of words recalled by subjects in the five different conditions on the three lists in both tests when scored by a strict positional criterion. Considering first the immediate recall results, it appears that recall was best in the loci and peg conditions, poorest in the rehearsal and imagery conditions, and intermediate with the link instructions. These impressions are confirmed by the statistical analyses. There was a reliable effect of conditions, $F(4, 290) = 34.85$, $MS_e = 38.90$, and of lists, $F(2, 290) = 11.08$, $MS_e = 12.04$, but the interaction between conditions and lists was not reliable, $F(8, 290) = 1.38$. Multiple comparisons with Fisher's LSD test indicated that recall in the loci and peg conditions did not differ but was superior to recall in the other three conditions. Also, recall in the link condition was superior to that in the imagery and control conditions, which did not differ reliably.

The serial position curves in immediate recall with the strict scoring criterion are

presented in Figure 2. The points represent the average of the three lists. The curves in Figure 2 are much more regular than those in Figure 1. With strict scoring, recall in the peg and loci conditions was better than that in the link condition in all but the first three serial positions. Recall was also worse in the rehearsal and imagery conditions than the other three conditions at almost all positions. Interestingly, recall in the imagery condition was poorer than that in the rehearsal condition at the primacy and recency parts of the serial position curve. Any similar tendency in the interior positions may have been masked by a floor effect.

The 24-hr delayed recall revealed a slightly different pattern of results. Although there was again a reliable main effect of conditions and lists and no Condition \times List interaction, the link, loci, and peg conditions did not differ. However, recall in each of these conditions was superior to that in the rehearsal and imagery conditions, which did not differ reliably. Thus the main difference between the pattern of results on the immediate and delayed tests was that in the former, the peg and loci subjects recalled considerably more words than did link subjects, but this difference vanished on the delayed test.

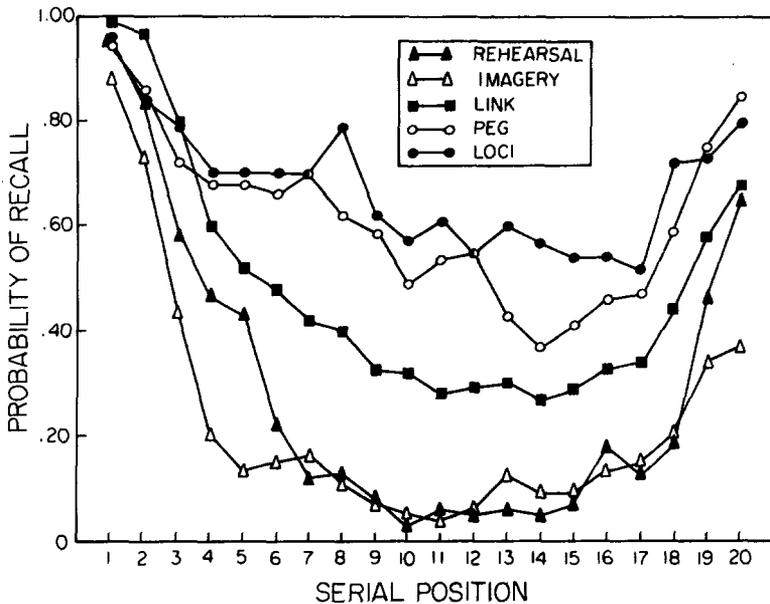


Figure 2. Serial position curves for the five conditions with strict positional scoring when averaged over the three lists.

Discussion

The results of the present experiment indicate that the three specific mnemonics studied all had beneficial effects on recall relative to conditions in which subjects were given elaborative rehearsal or simple imagery instructions. However, the effects were fairly small when subjects were scored by a lenient (free recall) criterion relative to the large effects found when subjects were scored by a strict positional criterion. The link, peg, and loci methods permit people to recall words in their correct order of input much better than do strategies that employ elaborative rehearsal or formation of separate mental images.

Subjects in the imagery condition who were instructed simply to convert words to mental images with no further specification of how to use these images in recall did recall more words than subjects in the rehearsal condition, but only in the immediate test with lenient scoring. On the delayed test with lenient scoring, the two conditions did not differ reliably, and when scored by the strict positional criterion, subjects told to use imagery actually recalled slightly fewer words than did subjects in the re-

hearsal condition. This slight impairment was evident in both the primacy and recency parts of the serial position curve.

It is clear that the benefit that accrued to the other mnemonic conditions (link, loci, and peg) was due to more than the instruction to convert the words to mental images. Recall under these conditions was generally superior to that in the imagery condition in both the immediate and delayed tests and with both the strict and lenient criteria. However, the advantage on the immediate test for the mnemonic conditions relative to the imagery condition was quite a bit smaller with lenient scoring than with strict scoring.

The link, loci, and peg methods provided for roughly similar levels of recall by the free-recall criterion, though the peg subjects were a bit low in both the immediate and delayed tests. However, differences in the effectiveness of the three techniques were revealed on the immediate test with the strict scoring criterion. In this case subjects in the peg and loci conditions recalled more words than did subjects in the link condition, presumably because the link method, being based on associative chaining between items, can only provide for accurate recall of order when subjects remember the

entire sequence. Forgetting of items from the sequence is more likely to disrupt the recall of the order of the other items than with the peg and loci methods, in which retention of order does not depend on successful recall of prior items. It is unclear why, by this reasoning, strict positional recall in the delayed test was not superior for the peg and loci conditions relative to the link condition. However, note that in this test, subjects had to assign a word both to the correct list and to the correct position within the list to receive credit. It may be that this extra complication drives down performance and masks differences among the conditions.

The results of the present experiment, unlike most others testing the effectiveness of various mnemonic devices, revealed large differences between the mnemonic techniques and appropriate control conditions with sensitive retention tests (see Figure 2). It seems likely that previous comparisons of the effectiveness of the techniques failed to find large differences because the tests used were inappropriate to assess the information encoded through use of the mnemonics. As has been pointed out by Morris, Bransford, and Franks (1977), in analyzing the effects of other types of encoding operations, the test one employs must be appropriate to assess the different kinds of knowledge obtained by the different encoding operations. In the terms of Morris et al. (1977), performance will be enhanced by transfer-appropriate processing, that is, when the knowledge obtained by the encoding operations is allowed to transfer appropriately to a new task. From the present results, it seems that the advantages of the peg and loci mnemonics lie primarily in that they allow one to retain items quite well in their appropriate order. Obviously this is an important feature in dealing with many tasks, such as remembering the points one wants to make in a speech or a lecture. However, for other purposes, when order is not as important, the link method may be just as helpful. The general point, which is hardly surprising, is that depending upon the purpose one has for remembering some information, different mnemonic strategies may be more or less appropriate.

The study of mnemonic devices has been largely isolated from the main body of memory research, as though they are isolated curiosities of little general interest to students of human memory. It can be argued, though, that the principles underlying the use of mnemonics are simply more efficient variations of normal memory functioning and that clues to normal functioning can be found in the study of mnemonics. When Miller (1956) discussed the dramatic improvement that resulted when his subject recoded binary digits into octal digits, he noted that "if you think of this merely as a mnemonic trick for extending the memory span, you will miss the more important point that is implicit in nearly all such mnemonic devices. The point is that recoding is an extremely powerful weapon for increasing the amount of information that we can deal with" (pp. 94-95).

The operation of the three mnemonic devices investigated in the present study (the link, loci, and peg systems) all seem to fit with the cue-dependent forgetting approach to problems of memory (Tulving, 1974). Remembering can be conceptualized as the product of information in the stored memory trace and that in the cues in the retrieval environment. In order for remembering to be successful, there must be a sufficient match or overlap of information in the retrieval environment with that in the stored trace (Tulving, 1976). Thus effective memory techniques should be those that provide for both good encoding of material and a set of effective retrieval cues. The link, loci, and peg methods all embody these principles. In each case mental images are used for encoding information. Although there is not general agreement on why imagery instructions aid verbal recall, one view (e.g., Paivio, 1971) is that they cause people to store information in two codes rather than only one. Besides encouraging better storage, all three techniques also include a system of retrieval cues. In the link method each recalled item is intended to serve as a cue for the next item through the interactive images created when the information is learned. From the present results, it would appear that this technique allows for as many items to be recalled as the others, but apparently the

cuing system in the link method does not allow people to keep track of the order of occurrence of items as well as the other systems do.

The peg and loci methods both provide good retrieval cues through either the number-rhyme scheme or the series of locations. These are sets of cues that have been designed not to be forgotten, so that the task then becomes one of attaching remembered events to the pegs or locations. Again, this is typically accomplished through interactive imagery. The loci and peg methods were equally efficient in the present study in allowing subjects recall of items in their correct order, but it seems likely that differences between them could be found with other tests. For example, peg subjects would probably be much more efficient than loci subjects at answering questions asking for specific numbered items (e.g., what was the 15th item on the list?).

One complaint against the use of mnemonics is that the most popular ones are restricted to remembering a discrete series of items, such as grocery lists, points in speeches, and so forth. However, it may be possible to create mnemonics for many different purposes by keeping in mind the two general principles of providing effective initial registration of the information and good retrieval cues for its later utilization. Lorayne and Lucas (1974), among others, have shown how the same basic techniques can be varied slightly to provide efficient remembering in many tasks and situations. The only limit to devising efficient systems for memorization would seem to be the rememberer's creativity in developing systems appropriate for the particular purpose at hand.

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Received January 14, 1980

Revision received April 23, 1980 ■