DOCUMENT RESUME

ED 118 609 TM 005 096

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TITLE Multiple Serial List Learning with Two Mnemonic Techniques.
PUB DATE [74]
NOTE 22p.

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage
DESCRIPTORS Associative Learning; Codification; *Comparative Analysis; Cues; Imagery; *Learning Theories; *Mnemonics; Recall (Psychological)

ABSTRACT

The classic mnemonic for learning serial lists, the method of loci, and its modern counterpart, the peg system, were compared by having subjects learn three 20-item serial lists. In addition to the type of mnemonic training, list imagery was either high (rated 6-7) or medium (rated 4-5), and instructions were either progressive elaboration (e.g., make a single image for each list position across the three lists), imagery, or verbal mediation. The verbal mediation instructions resulted in equal performance on both high and medium lists. The two imagery instructions resulted in higher recall than the verbal on high imagery lists and lower recall than the verbal on medium imagery lists. An absence of serial position effect was found for the two imagery instructed groups receiving high imagery lists. All other conditions showed a strong serial position effect. The comparison of the two mnemonic systems showed the peg method gave slightly higher recall on the high imagery lists, and the loci method gave slightly higher recall on medium lists. The results were discussed in terms of the subject's attempt to create an image for the medium imagery items interfering with finding an effective mediator. (Author)

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Mnemonic techniques making use of imagery have a long history. With the classic technique, the method of loci, a serial list such as the topics in a speech was learned by associating each item in the list with a location on a well known path. The user pictured the to-be-remembered item at the location appropriate to its order. To retrieve the list, the user imagined traveling to each locus to find what was pictured there.

Studies with this method have shown subjects using it to be superior to those receiving rote repetition instructions or to those given no special instructions (Ross and Lawrence, 1968; Groninger, 1971). Ross and Lawrence had five subjects learn four lists of 40 concrete nouns at one list per day. On the last day, 72 per cent recall was found for all lists. In addition, there was an absence of the classic serial position effect (i.e., recall was not worse in the middle of the list). Groninger found his loci group learned faster, recalled more, and made fewer serial position errors than the control group. He found the difference between the loci and control group increased at recall delays of one and five weeks.

The method of loci presents some control problems because the pathway tends to vary from one laboratory to another. To overcome this problem, the rhyming peg list was developed (see Paivio, 1971). It preserved the sequential and high imagery characteristics of the loci yet allowed

standardization of the mnemonic items. The pegs were words that rhymed with each ordinal position number. Typically, these were "one-bun", "two-shoe", "three-tree", etc. The rhyming characteristic made the mnemonic easy to learn.

The peg mnemonic aided in recall of high imagery lists. Bugelski (Bugelski, 1968; Bugelski, Kidd, and Segmen, 1968) had subjects learn six lists of ten items using either pegs or standard serial instructions. The peg group showed much higher performance for both immediate and total recall. With mnemonics, the rate of presentation must not be too fast. Bugelski et. al. found facilitation with pegs occurred when the lists were presented at rates of four or eight seconds but not at two seconds, a rate typical of rote studies. Like loci subjects, those using pegs showed almost no serial position decrement in the middle of a twenty item list (Persensky and Senter, 1969). They and others (Bower, 1970) interpreted this finding in terms of a reduction of interferences because the mnemonic had changed the serial task into a paired-associate one.

The peg and loci mnemonics appear to have similar effects at least when the material learned was fairly high in imagery. Going from high to low imagery in paired associates retards rate of learning. This effect appears to be most pronounced on the stimulus side of the pairs (Paivio, 1971). The effects of instructions also depend on pair imagery. Those subjects required to reproduce their mediators showed an interaction between instructions (verbal or imagery mediation) and pair imagery (Paivio

and Foth, 1970). Imagery instructions were best for concrete material whereas sentence instructions were best for abstract pairs. Concreteness and imagery have been found to be highly correlated (Paivio, Yuille, and Madigan, 1968).

Paivio (1971) attributes the gain from imagery instructions to the creation of a dual memory code. High imagery items are encoded both visually and verbally while low imagery items have only a verbal code. The high imagery items are better recalled because these items can be retrieved using either code. The existence of the dual code by itself aids paired associate and free-recall learning, but in serial learning the overlearned mnemonic is required to provide sequential information from the verbal store, because only the verbal code provides sequential information.

The use of the same mnemonic to learn several lists, progressive elaboration, has been studied by Bower and Reitman (1972) and Crovitz (1971). In these studies, subjects were instructed to form only one image for each peg or locus. Items from successive lists were then added to the appropriate image. Progressive elaboration was superior to instructions to form separate images for each list except on the last trial of immediate recall (Bower et. al.). After one week, progressive elaboration exceed the single image groups on all lists.

An alternative explanation for the effectiveness of the mnemonics is possible. The combination of instructions and mnemonic could cause

subjects to form efficient verbal mediators. Instead of the rote or uninstructed control groups, the appropriate control group to test this hypothesis is one instructed to form verbal mediators. When subjects were asked to report their mediators in a free-recall study (Boltwood and Blick, 1970), the narrative, a verbal-mediation mnemonic, was the most frequently reported. None of the subjects in this experiment reported using imagery. The narrative technique was found to be effective in learning 12 lists of ten items by Bower and Clark (1969). Mondani and Battig (1973) instructed subjects in both verbal and imagery mediation and then tested them on a list with both stimulus and response concreteness varied. Few imagery mediators were reported for abstract pairs. Good learners were marked by their ability to switch strategies.

The two mnemonics were compared in only one of the studies cited. In that one (Bower and Reitman, 1972), the method of loci was used only under progressive elaboration instructions. Item imagery, which was a critical factor in the effectiveness of instructions with paired-associates, was varied in only a few studies of serial lists. When imagery was varied, it was at the high and low ends of the Paivio et. al. norms (1968). Picking words from the low end severely limits the number of available items compared to the high end. Using words from the middle imagery range might provide additional information about the relation between the imagery dimension and learning.

Method

Subjects. The subjects were 102 introductory psychology students who were run in groups of four or five per experimental condition, according to a prearranged random schedule. In addition, the data from nine subjects were not used because of failure to learn their mnemonic list.

Materials and Design. The design was a mixed model with Between-subjects variables of mnemonic (peg or loci), instructions (progressive elaboration, imagery, or verbal mediation), and degree of list imagery (high or medium). Within subjects variables were Lists and Serial Position (20 items per list). An additional Between-subjects variable, (six high and six medium imagery lists) was used to control for specific list differences.

The high and medium lists were selected from two pools of items randomly selected from the Paivio et. al. norms. High imagery lists had items rated 6.00 to 7.00 on imagery while on the medium lists had items rated 4.00 to 5.00 on imagery. Words were limited to nine letters to minimize length differences across imagery level. The words were assigned to six lists in each imagery level so that associations within lists were at a minimum.

The loci mnemonic consisted of a list of twenty landmarks (e.g., buildings, malls, stores, etc.) that were found on a walk around campus well known to undergraduate students. The peg mnemonic was a local version of the one used by Bower and Reitman. For numbers greater than

ten, strong associates (e.g.,"sixteen-kiss", "eighteen-vote", etc.) were used instead of the "penny-one" rhymes.

All stimuli were photographed and projected as negatives one at a time on a screen in front of the subjects' table. The mnemonic lists were presented in constant serial order and had a digit above each word corresponding to the ordinal position. This digit was not included on the words for the test lists. An electronic timer controlled the presentation rate during the lists while a stopwatch was used to time the test periods. All responses were recorded in an answer booklet.

Procedure. The sequence of events consisted of four parts: (1) four study-test trials on the mnemonic list, (2) presentation of the mediation instructions, (3) one study-test trial on each of the three test lists, and (4) a cued recall over all three test lists. In the initial instructions, subjects were told that the experiment would require the learning of a number of lists in serial order. The experimenter then read through the mnemonic list (i.e., peg or loci) and explained either that the items were associated with the first twenty numbers or that the items were a list of twenty locations on a walk around campus. Standard study-test serial instructions were then given for learning the mnemonic list. The lists were presented at a 5-second rate with a 2-minute test trial after each study trial. The subjects were reminded to write the lists in serial order before the first test trial.

The mediation instructions were given at the conclusion of the last mnemonic test trial. The experimenter explained that the list they just learned could be used to learn the subsequent lists. The instructions differed from this point according to the condition. Verbal mediation groups were told that by forming an active sentence using the mnemonic word as the subject and the new word in that serial position as the object it would help them learn the list. Imagery and progressive elaboration groups were told they could remember the list better if an interactive image was made using the mnemonic item and the corresponding list item. The progressive elaboration groups were given the additional instructions that it was easier to learn subsequent lists if images for the new items were incorporated into the original image for each serial position. Two examples were given using the same words for all groups. The subjects were told there would be only one trial on each of the lists so they should learn as many words as possible on each trial. They were reminded to write the words in order and told that any words recalled out of order should be written in a separate place on the answer sheet. These later recalled words were scored as serial position errors. Lists were presented at a 10-second rate with a 4 1/2-minute test period after each list.

After the test on the third list, a 5-minute cued recall test was given over all three lists. The answer page for this task consisted of

the twenty pegs or loci and spaces for the words on each list. At the end of the cued recall, subjects were asked to fill out a questionnaire on the techniques used to learn the lists.

Results

All lists were scored for number correct by both serial and free recall criteria. The two methods gave similar results so all references are to serial scoring unless otherwise noted. Unweighted means analysis of variance were used for all tests.

Mnemonic Lists. All but one subject were able to recall the twenty mnemonic items by the fourth trial. A mixed model analysis of variance with Between-subjects factors Imagery/Mnemonic Type/Instructions/Version and Within-subjects factor Trials showed some differences in recall of the mnemonic lists. The mnemonic column of Table 1 shows the mean

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Insert Table 1 about here

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number of correct items across four mnemonic trials. Groups that later received medium-imagery lists with imagery instructions showed low recall on the mnemonic lists while those groups that later received the same lists with verbal mediation instructions showed high recall. This gave a significant Imagery X Instruction interaction, F (2,78) = 3.85, $p < .05$. Low recall was shown by groups getting peg lists while higher recall was shown by groups getting loci lists who were to receive verbal mediation

instructions. This yielded a significant three-way interaction of Imagery X Instructions X Mnemonic, F (2,78) = 6.90, $p < .01$.

Immediate Recall. A mixed model analysis of variance with Between-subjects factors Imagery/Mnemonic Type/Instructions/List Version and Within-subjects factors Lists/Serial Position was used with the immediate recall data. As expected, high imagery words were better remembered than medium with F (1,78) = 33.55, $p < .01$. These data are shown in the study-test column of Table 1. Performance increased across lists and showed a warmup/practice effect from the first to the second and third lists, (means were 10.4, 11.6, and 11.5 respectively) giving a List effect F (2,156) = 4.79, $p < .01$. A marked interaction was found between type of instructions and list imagery. On high imagery lists, imagery instructions yielded higher performance than did verbal mediation instructions. But on medium imagery lists, the reverse was true. Examination of the second column of Table 1 shows that item imagery affected recall only for the subjects given some type of imagery instructions. The Instruction X Imagery interaction was significant for free recall scoring F (2,78) = 4.59, $p < .05$ but only marginally significant for serial scoring F (2,78) = 2.70, $.05 < p < .10$. Post hoc tests showed the differences between high and medium imagery groups were significant for both types of imagery instructions, $p < .05$, and nonsignificant for verbal mediation instructions, $p > .05$.

Examination of serial position effects showed that most of the differences in recall were for the items in the middle of the lists. An overall significant quadratic trend was found across serial position F (1,78) = 122.16, $p < .01$. The quadratic serial position trend showed a significant interaction with imagery F (1,78) = 20.44, $p < .01$, and with list F (2,156) = 6.79, $p < .01$. On high-imagery lists, the verbal mediation groups showed a typical serial position curve. In contrast, both imagery instructed groups showed almost constant recall across all serial positions. Figure 1 shows the interaction of Serial Position X Imagery X Instructions F (38,1482) =

Insert Figure 1 about here

1.85, $p < .01$. The solid lines are the least squares fit for a second degree polynomial. The trend analysis showed a significant quadratic Serial Position X Instructions X Imagery interaction F (2,78) = 5.96, $p < .01$. On medium lists, all groups exhibited the typical serial-position effect.

Serial position effects were found for all three lists as supported by a significant linear Serial Position trend F (1,78) = 18.75, $p < .01$. The linear Serial Position X List interaction was significant F (2,156) = 6.47, $p < .01$, as was the interaction with Imagery X List F (4,156) = 2.67, $p < .05$.

The two mnemonic techniques were not equivalent across imagery levels. The peg list was inferior to loci for medium-imagery lists given verbal-mediation instructions as shown in column two of Table 1. This gave a significant Imagery X Instructions X Mnemonic interaction F (2,78) = 3.28, $p < .05$.

Cued Recall. A mixed model analysis of variance was also performed on the cued recall data with Between-subjects factors Imagery/Mnemonic Type/ Instructions/Version and Within-subjects factors Lists/Serial Position. Column three of Table 1 shows that recall was higher for high-imagery lists yielding a significant imagery effect F (1,78) = 19.81, $p < .01$. Instead of the warmup observed in the immediate recall data, cued recall showed a strong recency effect across lists 1 to 3 (mean correct were 4.6, 6.3, and 8.7 respectively) giving a significant list effect F (2,156) = 25.90, $p < .01$. An analysis of variance that included the two recall measures as a factor, delay, showed the Delay X List interaction was significant F (2,156) = 25.69, $p < .01$.

Verbal-mediation instructions had an even stronger effect than on immediate recall. This gave a significant Instruction X Imagery interaction F (2,78) = 4.70, $p < .05$. There was a mean difference of six items between the two list imagery levels for groups receiving imagery instructions and a difference of less than one item for groups receiving verbal-mediation instructions. These data are shown in the cued recall column of Table 1. Post hoc tests showed that the difference between high and medium lists were significant, $p < .05$, for both imagery instruction conditions, $p < .05$, but not for verbal mediation groups.

Large differences in serial-position curves were not evident in the cued-recall data. The only significant effects were serial position F (19,1482) = 27.05, $p < .01$, linear serial position F (1,78) = 103.59, $p < .01$, and quadratic serial position F (1,78) = 25.12, $p < .01$. The imagery and verbal mediation instructions resulted in almost parallel serial-position curves. As expected, no recency effects were found within lists since this was a free-recall task. Groups receiving the peg mnemonic did better on high-imagery lists while groups receiving the loci mnemonic did better on the medium-imagery lists giving a significant Mnemonic X Imagery X Serial Position interaction F (19,1482) = 2.21, $p < .01$. This was different from the immediate recall results as shown by a significant Imagery X Instruction X Mnemonic X Delay interaction F (2,78) = 6.14, $p < .01$.

The two versions of the list were not significantly different on either immediate or cued recall. There were, however, some significant higher order interactions of Serial Position and the two versions of the lists. These were judged to be the result of the lists not being matched on a word for word basis and were considered artifactual.

Discussion

The interaction found between mediation instructions and list imagery agrees with the predictions of the dual-encoding hypothesis (Paivio, 1971). According to the hypothesis, all items are encoded

verbally, and in addition, imagery instructions lead to visual encoding. The ease of creating this code is directly related to the level of imagery. This type of interaction has been found for within-list experiments using paired-associate learning (Paivio and Foth, 1970; Robbins, Brag, Irvin, and Wise, 1974). In these studies, as in the current one, imagery instructions resulted in higher performance on high-imagery lists while verbal-mediation instructions yielded higher performance on low imagery ones.

In the dual encoding hypothesis, the verbal store is characterized by serial position effects because it is arranged sequentially. The visual store, however, should not show sequential effects because it is a parallel system. If interference from the ends of a list is taken as the source of the serial position effect, then the magnitude of this effect would be a measure of interference. Only the verbal-mediation groups showed any serial position effect on high-imagery lists in agreement with the hypothesis that it has access to the verbal store. All instruction groups showed serial position effects on medium lists arguing that the visual store was not available for this type of item. Larger losses for verbal mediation groups at the ends of the lists on cued recall also argue for greater interference for these groups. Considering medium-imagery lists only, the imagery instructed groups evidenced the greatest loss over the delay. This is consistent with the hypothesis that these groups do not have a good visual code.

The lack of a difference between single image and progressive elaboration is puzzling. Bower and Reitman found that progressive elaboration instructions increased recall relative to single-imagery instructions and reduced between-list interference. It may be necessary to give the subjects practice on the technique, as they did, for it to be effective.

It should be noted that the medium-imagery lists produced recall patterns similar to low-imagery lists in other studies. In light of this, the concept of imagery as a continuous variable within subjects should be questioned. It may be that imagery is a binary variable (i.e., a word can be imaged or it cannot) that appears continuous only because of large individual differences. The large standard deviations in the midrange of the Paivio et. al. norms is in accord with this hypothesis. Additional research on this question is needed.

The peg and loci mnemonics did not show equivalent effects. Because the mnemonic differences involved interaction with the other main variables, any conclusions must be guarded. The most striking differences between mnemonics involved groups getting verbal-mediation instructions. Loci subjects showed slightly better performance with medium-imagery lists for both immediate and cued recall. The peg subjects under verbal mediation, however, showed poor performance on medium-imagery lists for both recall tasks. A possible explanation

for the difference in mnemonics is that narratives were used to remember the medium lists. These have been reported as an effective technique for learning serial lists (Bower and Clark, 1969), and might be especially useful with the medium-imagery material. If this was the case, the inherent theme in the walk around campus would provide a good organization for the narrative using loci.

For imagery instructions, the two mnemonics were similar. There was a slight advantage for the peg method, especially on medium imagery lists. On the other hand, loci groups showed smaller losses when measured on the cued recall task. Possibly the subjects found the peg items easier to recall during learning and thus had more time to generate images. Longer presentation times facilitate the effect of imagery instructions in paired-associate learning (Bugelski, Kidd, and Segmen, 1968). If the difficulty is in the retrieval of the loci mnemonic, then a cued-recall task should facilitate the loci more than the peg groups which did happen. The results for the loci groups with progressive elaboration instructions are hard to understand. On high-imagery lists, the group showed the highest level of immediate recall and the greatest loss in cued recall. Loci groups receiving single-imagery instructions, by contrast, showed smaller losses than the corresponding peg groups.

If the progressive elaboration groups are not considered, the loci groups show less loss from immediate to cued recall than any peg condition. With extended pretraining, the loci might well become the best mnemonic under all conditions. This would not be so surprising in view of its long history in the art of memory.

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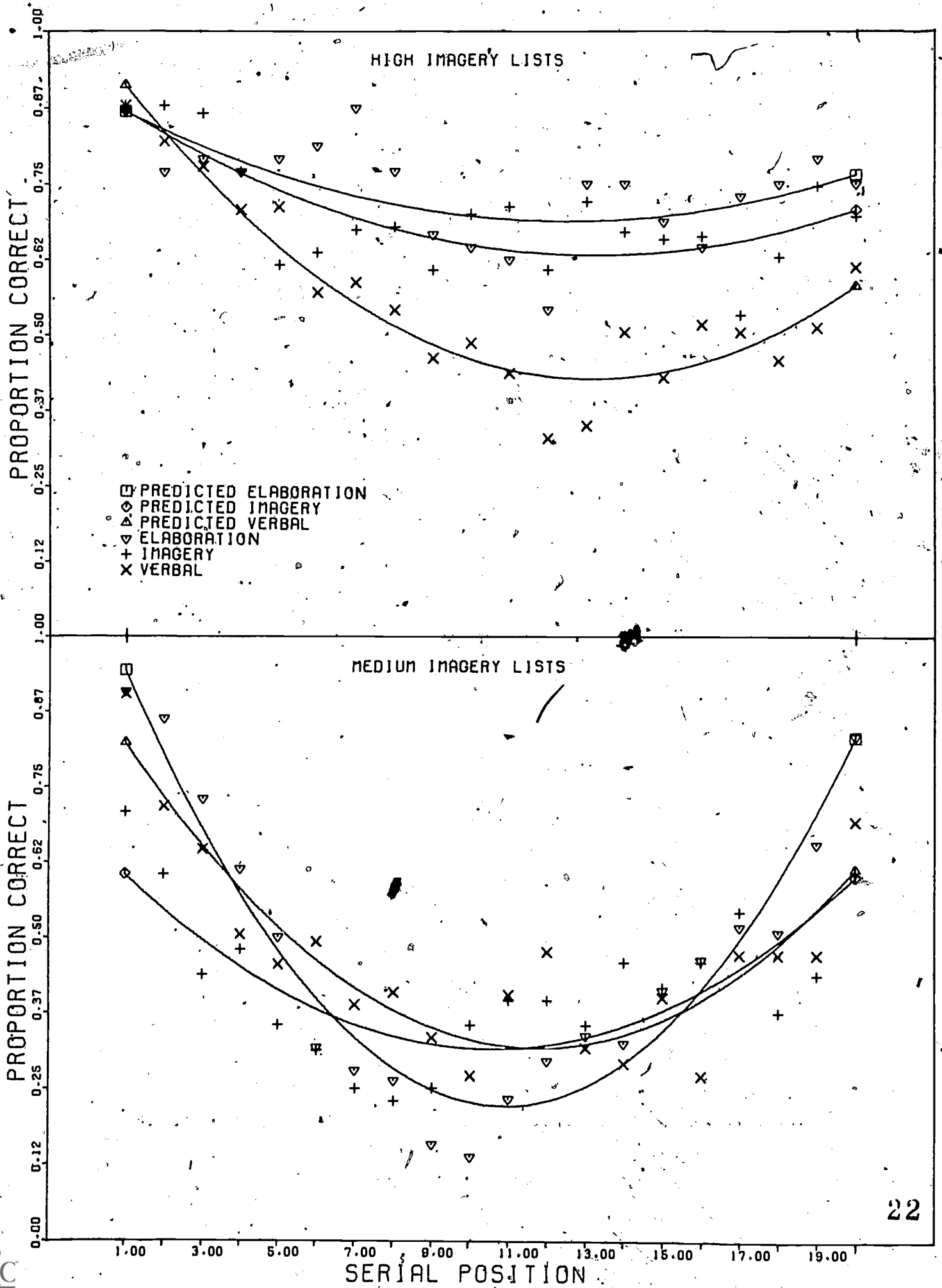
Table 1

Mean number of words correct using serial scoring for phases (1) mnemonic learning (4 trials), (2) one study-test trial for each of 3 lists, and (3) cued recall over all 3 lists.

M	I	P	Phase		
List Imagery	Instructions	Mnemonic	Mnemonic Learning	Study-Test Trials	Cued Recall
High	Elaboration	Peg	18.2	14.3	11.0
		Loci	17.7	15.3	7.7
	Imagery	Peg	17.9	14.5	9.4
		Loci	16.9	13.3	9.7
	Verbal	Peg	14.9	11.6	6.3
		Loci	18.9	10.9	6.8
Medium	Elaboration	Peg	17.0	10.5	3.7
		Loci	17.8	8.2	3.2
	Imagery	Peg	16.7	9.1	4.2
		Loci	15.6	7.8	3.2
	Verbal	Peg	18.3	6.8	4.3
		Loci	17.6	12.0	8.6


HIGH IMAGERY LISTS
MEDIUM IMAGERY LISTS
PROPORTION CORRECT
1.00
0.87
0.75
0.62
0.50
0.37
0.25
0.12
0.00
PREDICTED ELABORATION
PREDICTED IMAGERY
PREDICTED VERBAL
ELABORATION
IMAGERY
VERBAL
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
SERIAL POSITION