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Rehearsal and Modality Effects on Delayed Recall of Continuously Presented Paired-Associates

Donna Lynn Breitenstein

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REHEARSAL AND MODALITY EFFECTS ON DELAYED RECALL OF

CONTINUOUSLY PRESENTED PAIRED-ASSOCIATES

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A Thesis

Presented to

The Faculty of the Department of Psychology

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

———————

by

Donna L. Breitenstein

1971

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

Master of Arts

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ABSTRACT

Ss were presented a list of stimulus-response (S-R) pairs, in which each stimulus was one of four two-digit numbers and each response was a letter. Ss were instructed to remember the most recent response to each stimulus. Trials consisted of a test of one of the pairs and presentation of a new pair. The lists alternated presentation and test, with zero to six intervening trials (lags) between presentation and test of a particular stimulus. To study the effect of modality on recall, lists were presented to each S either visually or orally. During the three second study period following the presentation of each S-R pair, Ss performed in one of three conditions: saying the S-R pair aloud while writing digits (oral rehearsal), writing the pair while saying digits (written rehearsal), or writing digits while saying the alphabet (no overt rehearsal). In each condition the non-rehearsal task was to limit Ss rehearsal to the type being studied, by focusing other modalities on the interferring tasks. Ss were presented two lists to determine if mode of output affected recall. For one list the test was a spoken probe and Ss said aloud their responses; for the other list, the probe was presented visually and Ss wrote their responses.

Recall decreased as the lag increased. This was expected since recall decreases with the amount of intervening information. Recall was significantly better with oral presentation than with visual. This supported theories which claim that information is stored in an auditory form, requiring visual stimuli to be recoded. Mode of output had no effect except in interaction with presentation modality and lag. The general superiority of recall after oral presentation resulted in better recall with oral presentation than with visual presentation for both modes of output.

Recall after oral rehearsal was significantly better than recall after either written rehearsal or no overt rehearsal. Since both written and oral rehearsal assured that S attended to the stimuli, but only oral rehearsal increased recall, attention was not the critical factor. Instead, the mode of rehearsal affected recall. Oral rehearsal improved recall of items in the auditory store. The lack of difference between recall after written rehearsal and no overt rehearsal suggested that when rehearsal is not oral, the type of rehearsal does not matter.

REHEARSAL AND MODALITY EFFECTS ON DELAYED RECALL OF

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INTRODUCTION

Memory consists of a sequence of registration, storage, and retrieval. One reason for failure to recall may be that the incoming stimulus was not attended to and the initial registration of the item decayed. Items may be registered without being attended to, but some degree of attention is necessary for a trace to be stored (Waugh and Norman, 1965; Atkinson, Brelsford and Shiffrin, 1967; Bower, 1967).

Rehearsal

Rehearsal is one means of focusing attention on the incoming stimuli. Rehearsal strengthens the item in memory and transfers it to a more permanent memory store. Rehearsing by saying items aloud has been found to improve memory.

Murray (1965, 1966) found that saying aloud items in a visual serial list produced better recall than when items were read silently. When Murray (1966) averaged performance over all presentation rates (1-4 letters per second), he found recall was better after saying aloud than after whispering, and better after whispering than mouthing silently. Differences between levels of vocalization were greater for faster presentation rates than slow rates. Murray (1965) suggested that verbalization caused $\underline{S}$ to give more attention to the stimulus than when it was read silently.

Ellis (1969) found that verbalization increased the recency part of the serial position curve, but depressed the primacy part. Ellis

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explained that recency was facilitated because oral activity increased overall attention and gave additional sensory clues to strengthen the Primary Memory trace. Rundus and Atkinson (1970) tape recorded S's rehearsal during presentation of a list for free recall. Ss had been told to study items aloud and were given no restrictions on choice of items or rate of rehearsal. Rundus and Atkinson found that items presented early in the list were rehearsed more than later items. Number of items recalled was an increasing function of amount of rehearsal, so primacy items had high probability of recall. Recency effects were due to the high probability of last items begin rehearsed just before recall.

Brelsford and Atkinson (1968) studied the effects of type of rehearsal on recall of visual stimuli in a continuous presentation task. The number of intervening trials between presentation and test of an item was called the lag. In the condition for overt rehearsal, Ss were told to say aloud the stimulus-response pair twice; Ss were supposed to pace their verbal rehearsal so it filled the three second time period. For covert rehearsal Ss were simply told to remember the items. There was better recall with overt rehearsal; the greatest difference between types of rehearsal was for lags 0 - 5. Brelsford and Atkinson admit that this finding is not surprising since overt rehearsal assures that S will attend to the stimulus and rehearse it at least twice, while such an assumption cannot be made with covert rehearsal. However, the interaction of type of rehearsal with lag indicated that the difference was due to more than attention. The covert rehearsal curve decayed exponentially, but the overt rehearsal

curve was an S-shaped function. To explain the rehearsal-lag inter-action Brelsford and Atkinson proposed that type of rehearsal affected the probability of entering a memory buffer, and the probability of being eliminated from it.

In each of the preceding studies the items were presented visually. Corballis (1966) compared spacing of rehearsal for visual and oral presentations. He found no difference for primacy positions, but in recency positions, recall of orally presented items was superior to recall of visual items. This suggests that recall may also be affected by mode of presentation.

Modality Differences

Most current theories hypothesize that initial registration of stimuli may be auditory, visual, or both, but the next level of storage is exclusively auditory (Tulving and Madigan, 1970). Hintzman (1967) suggested that visual stimuli were recoded by subvocal rehearsal into a temporary auditory or articulatory representation. Atkinson and Shiffrin (1968) also suggested that storage is probably in some auditory form, which they call auditory-verbal-linguistic store (a.v.l.). Information appears to decay from a.v.l. in 15-30 seconds, but a limited amount can be maintained longer by rehearsal. Atkinson and Shiffrin feel that lack of research does not allow storage in other modes to be completely excluded from consideration. According to Sperling's (1967) model, visually presented material is first stored in visual storage, then transferred into auditory storage. The results of Parkinson, Parks and Kroll (1971) indicate that visual stimuli may be stored for at least several seconds, as the appearance of the stimulus rather then its name.

Bahrick and Boucher (1968) hypothesized that visual stimuli may lead to either verbal or nonverbal storage. Visual stimuli may be immediately recoded for verbal retention, or may be stored nonverbally and recoded at the time of retrieval for verbal recall. Broadbent (1967) and Wickelgren (1969) discussed the possibility of a common encoding in short-term memory that is neither auditory nor articulatory, but an abstract verbal modality. Craik (1969) hypothesized that once an item was attended to, the input modality was no longer important; he suggested that short-term storage is in some neutral modality. Cermak (1970) suggested that several types of encoding, requiring different amounts of time for encoding and with different decay rates, may occur when an item is presented.

Corballis (1966), Murdock (1966, 1967) and Craik (1969, 1970) found superior recency recall with oral presentation of serial lists. Murdock (1969) used a spatially distributed array for auditory and visual presentation. Even when defined spatially, recall of oral items was more accurate than recall of visual ones. Cooley and McNulty (1967) found that as the retention interval increased in a single-presentation task, the modality differences decreased. Using recall tasks and recognition tasks, Murdock (1968) concluded that modality differences in recall were due to storage differences.

Mode of Output

Since input modality affects storage it may be questioned whether mode of output causes differences in recall due to retrieval differences. Chase and Calfee (1969) studied recognition with auditory and visual presentation and tests. One experiment varied the modes within Ss

and a second varied them between Ss. Both experiments found no significant differences in reaction time between presentation modes, but reaction time was significantly faster for auditory tests than visual tests. Comparison within Ss indicated significantly faster processing rates when presentation and test were in the same mode than when they were in different modes.

Craik (1970) tested written and spoken free recall of visual and oral lists. Recency recall was significantly better when written rather than spoken. There were no interactions between input and output modes. Murray (1965) found overall free recall of visual items, some of which had been verbalized at presentation, was better when recall was written; however, Murray (1966) used a similar task and did not obtain a significant difference between modes of recall, although there was a tendency for written recall to be superior. On half the trials Murray (1966) told Ss prior to presentation whether to say or write the items they recalled; on the other trials Ss did not know the mode of recall until after the list had been presented. Results showed little difference between prior knowledge and post-list knowledge of the recall mode.

Studies of output modality are conflicting. Murray (1965) and Craik (1970) found better recall when answers were written rather than spoken; Murray (1966) found no difference; and Chase and Calfee (1969) found faster reaction time to oral tests.

Continuous Presentation Technique

Shepard and Teghtsoonian (1961) studied the continuous presentation method of presenting verbal material, which maximized interference by filling the interval between presentation and test with more presentations of the same kind. S was given a sequence of items and had to retain the most recent ones throughout the entire sequence. Forgetting of items in a series was obtained by testing after different numbers of intervening items. Katz (1966) used the continuous presentation technique to study recall as a function of intervening items in a list 220 items long. He believed the continuous presentation method presented a more stable situation than single item or short list methods. There were no primacy effects and proactive effects were found to be constant throughout the sequence. Katz described the continuous presentation method as a means of obtaining large amounts of data in a homogeneous situation.

Brelsford, Keller, Shiffrin, and Atkinson (1966) and Atkinson et al. (1967) studied recall of paired-associates using the continuous presentation method. Recall was found to be a decreasing function of the number of study-test pairs interpolated between presentation and test. Performance was nearly perfect for lag zero, dropped sharply for lag one, then gradually decreased. Brelsford et al. noted that beyond ten lags performance was close to chance. Both studies varied the size of the stimulus set (4, 6, or 8 items) and found that recall was better for smaller stimulus sets. The continuous presentation method was used in the present experiment to provide experimentally controlled interference between presentation and test.

The present experiment used the continuous presentation technique to study the effects of rehearsal on recall of paired-associate items. Recall was expected to be reduced by intervening items, but effects of rehearsal and modality were of primary interest.

Two types of rehearsal were studied--saying items aloud (oral rehearsal), and writing the items (written rehearsal). When rehearsal was critical in one mode, rehearsal in another was limited by requiring S to count digits. In the no overt rehearsal group Ss performed both an oral task (saying the alphabet) and a writing task (writing digits). There were no conditions without specified tasks since this would not give information concerning which type of rehearsal was, or was not, being used. Peterson (1969) has shown that Ss can do two tasks at the same time. The degree of attention required was directly related to the difficulty of the task.

In this study presentation was oral and visual. Recall was both written and spoken to determine if there was an input-output modality interaction. Output modality was varied within Ss. Murray (1965, 1966) and Craik (1970) used within S designs in their studies of output modalities. The results of Chase and Calfee (1969) further justify the within Ss design since they found the same results for within Ss and between Ss experiments.

It was expected from earlier studies that saying items aloud would produce better recall of visual lists than studying covertly. If improved recall after oral rehearsal is due to S attending more to items he has to rehearse aloud, there would also be improved recall when S was required to write the items. If attention is the critical variable, recall of oral lists would also be increased with overt rehearsal.

Previous studies finding a difference in recall after different kinds of rehearsal (Murray, 1965, 1966; Brelsford and Atkinson, 1968; Ellis, 1969) have used visual lists. However, improved recall may have been produced by S storing his oral reproduction of the item; since oral items are recalled better than visual items, the verbalization would facilitate recall. If this is the case, recall would be reduced when rehearsal, as well as presentation, is not oral.

Input-output modality interaction was studied. Chase and Calfee (1969) found faster reaction time when tests were oral, but studies by Murray (1965) and Craik (1970) found written recall to be superior. If memory stores are organized by input moadlity, recall may be facilitated when input, rehearsal, and output were in the same mode rather than different ones.

METHOD

Subjects

Sixty introductory psychology students, 30 males and 30 females, served as <u>S</u>s.

Apparatus

Oral lists were recorded and played by a Wollensak (model 1520) tape recorder. Visual lists were filmed on 16 mm movie film and projected by a Perceptoscope (model 5102-2, Perceptual Development Laboratories).

Stimuli and Responses

Stimuli were the four two-digit numbers: 33, 44, 55, and 66. Responses were not from the first part of the alphabet to prevent confusion between the response letter and the letters <u>S</u>s were saying in the control group. The letters K, L, N, O, R, S, T, U, Y were chosen because they did not look nor sound similar to each other. Pairs were formed so each response occurred with each stimuli about an equal number of times.

A list was constructed with six the greatest lag. It was not possible to devise a list in which each lag 0 - 6 occurred equally often so each occurred approximately the same number of times. There were 27 tests after lags 0 and 6, 28 tests after lags 2, 3, and 4, and 29 after lags 1 and 5. Pairs were ordered so each response was paired with no more than one stimulus at a given time. Each stimulus

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was presented for forty-nine trials in the list, about equally often

at each lag. In addition, there were four trials at the beginning of

the list, one with each stimulus, to test the four initial study

pairs. The first four trials were not included as data. One list

was formed and a second was derived from it by direct substitution

of one stimulus and one response for another.

Procedure

Ss were tested individually in one of six conditions; each S

received lists in one of the two presentation modalities and performed

one of the two types of rehearsal or no overt rehearsal. There were

ten Ss in each group. Each S was tested on two lists--one with visual

stimulus probe and written recall, the other with oral probe and

spoken recall. Half the Ss were given the visual probe list first;

the oral probe list was presented first to the other Ss. With oral

stimulus-response presentation, the visual probe was shown S on a

5" x 8" index card. In groups with visual presentation, E spoke the

oral probe. When input and output modalities were the same the probe

was presented by the same apparatus presenting the pairs to be

learned. When the stimulus probe was oral Ss said the most recent

response paired with that stimuli; E recorded S's response. Ss wrote

the most recent response on a numbered answer sheet when the stimulus

probe was presented visually. Ss were instructed not to guess when

they did not remember the response.

Initially four pairs were presented for study in this order:

(a) the word "study" for one second, (b) a stimulus-response (S-R)

pair, (c) three second interval for rehearsal. Steps a - c were

repeated three times so each of the four stimuli were introduced with

a response. Then trials began consisting of: (a) word "test" for one second, (b) stimulus probe (one of the two-digit numbers), (c) three second interval for $\underline{S}$ to recall the response to the stimulus presented, (d) word "study" for one second, (e) S-R pair, of which the stimulus is the one just tested in step b, with a new response, (f) three second interval for rehearsal. The sequence then repeated for the second trial: (a) "test", (b) a stimulus probe, which may or may not be the one presented in the previous trial, (c) recall interval, (d) "study", (e) S-R pair, of which the stimulus is the one just tested, with a new response, (f) rehearsal; etc. When presentation was visual $\underline{E}$ said the words "study" and "test" when they appeared. This was necessary to alert $\underline{Ss}$ to look up from their rehearsal or answer sheet to see the stimulus.

For oral rehearsal $\underline{Ss}$ said aloud the S-R pair; they were required to speak continuously and for the entire interval. While repeating the S-R pair, $\underline{Ss}$ were writing digits beginning 1, 2, 3, etc. For written rehearsal $\underline{Ss}$ wrote down the S-R pair; again they were required to write for the entire rehearsal interval. While writing, $\underline{Ss}$ counted digits aloud. No overt rehearsal $\underline{Ss}$ wrote digits and said the alphabet.

$\underline{Ss}$ read the instructions and asked $\underline{E}$ any questions. $\underline{Ss}$ first performed on six trials (more if the individual needed) without tests to practice the tasks he would be doing during the study interval. After any necessary corrections were made $\underline{Ss}$ were given a practice list with ten complete trials, then the two experimental lists. There was a five minute break between the two experimental lists.

RESULTS

The percent of correct responses at each lag was computed for

each S. The mean percent of correct responses is presented in Table I.

A split-plot analysis of variance was performed for the variables

presentation method, mode of recall, rehearsal, and lag (2 x 2 x 3 x 7),

with ten Ss in each condition. Table 2 shows the results of the

analysis. Presentation method, rehearsal, and lag were significant

main effects; the only significant interaction was of presentation

method, recall mode, and lag.

As expected, recall decreased as the lag increased; the greatest

loss of information was after lags zero and one. Mean percent of correct

responses at each lag and results of a t-test for difference between lags

are in Table 3. Even after six intervening trials, mean performance had

not quite reached chance of guessing the one correct response out of

the nine possible responses (11.111%).

Overall, recall after oral rehearsal was significantly better than

recall after written rehearsal or after no overt rehearsal. Table 4

presents the t-values for comparison of types of rehearsal. The effects

of rehearsal over lags is shown in Figure 1. Recall in all groups

greatly decreased with increasing lags, but recall after oral rehearsal

decreased less than after written rehearsal or after no overt reherasal.

When the lag was zero, performance was nearly the same after oral and

written rehearsal. With a lag of one, percent correct after written

rehearsal was less than after oral rehearsal, and about the same as the

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TABLE I

MEAN PERCENT OF CORRECT RESPONSES

Presen-tation	Rehearsal	Recall	Lag 0	1	2	3	4	5	6
Oral	Oral	Spoken	99.630	51.379	37.857	35.714	29.643	28.276	25.556
Oral	Oral	Written	98.889	57.241	41.786	33.929	27.500	30.345	22.963
Oral	Written	Spoken	98.519	45.862	26.786	22.500	22.857	21.035	17.778
Oral	Written	Written	100.000	55.862	30.357	20.357	17.500	16.897	10.741
Oral	No Overt	Spoken	97.037	47.241	32.857	27.857	21.429	19.655	17.778
Oral	No Overt	Written	95.185	56.207	31.786	21.786	20.714	21.724	16.667
Visual	Oral	Spoken	98.519	42.759	25.357	20.357	17.500	15.173	14.815
Visual	Oral	Written	98.519	49.655	28.929	21.786	18.929	17.241	13.704
Visual	Written	Spoken	96.667	44.483	25.000	20.357	11.429	16.207	9.630
Visual	Written	Written	94.815	33.793	22.857	19.286	11.786	13.448	11.482
Visual	No Overt	Spoken	87.407	41.724	29.643	24.286	23.214	15.517	18.148
Visual	No Overt	Written	80.741	36.207	25.715	22.857	20.000	15.862	14.444

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TABLE 2

SUMMARY TABLE OF ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Mean Square	F
Between Subjects	419	1701.857	
A (Presentation Method)	1	9665.338	30.245**
C (Rehearsal)	2	2604.515	8.150**
D (Lag)	6	95090.300	297.559**
A × C	2	484.426	1.516
A × D	6	124.416	0.389
C × D	12	189.220	0.592
A × C × D	12	239.939	0.751
Subjects Within Groups	378	319.568	
Within Subjects	420	84.263	
B (Recall Method)	1	71.140	0.848
A × B	1	85.677	1.020
B × C	2	197.483	2.353
B × D	6	91.345	1.088
A × B × C	2	106.102	1.264
A × B × D	6	193.139	2.301*
B × C × D	12	34.006	0.405
A × B × C × D	12	65.717	0.783
B × Subjects Within Groups	378	83.923	
Total	839	892.096	

* $p < .05$

** $p < .001$

TABLE 3

MEAN PERCENT OF CORRECT RESPONSES AT EACH LAG AND t-VALUES

FOR COMPARISON OF PERFORMANCE AFTER EACH LAG

Lag	Mean % Correct	Compared With Lag						
		0	1	2	3	4	5	6
0	95.494	-	21.068**	28.416**	30.866**	32.620**	33.021**	34.381**
1	46.868		-	7.347**	9.797**	11.551**	11.952**	13.313**
2	29.911			-	2.450*	4.204**	4.605**	5.966**
3	24.256				-	1.754	2.155*	3.516**
4	20.208					-	0.401	1.762
5	19.282						-	1.360
6	16.142							-

* p < .05

** p < .001

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TABLE 4

t-VALUES FOR COMPARISON OF PERFORMANCE

AFTER REHEARSAL

Type of Rehearsal	Mean % Correct	Compared with		
		C_1	C_2	C_3
Oral (C_1)	39.427	–	3.919**	2.844*
Written (C_2)	33.510		–	1.074
No Overt (C_3)	35.132			–

* $p < .01$

** $p < .001$

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FIGURE I

MEAN PERCENT OF CORRECT RESPONSES AFTER

EACH TYPE OF REHEARSAL

O———O Oral Rehearsal

△——△ Written Rehearsal

□----□ No Overt Rehearsal

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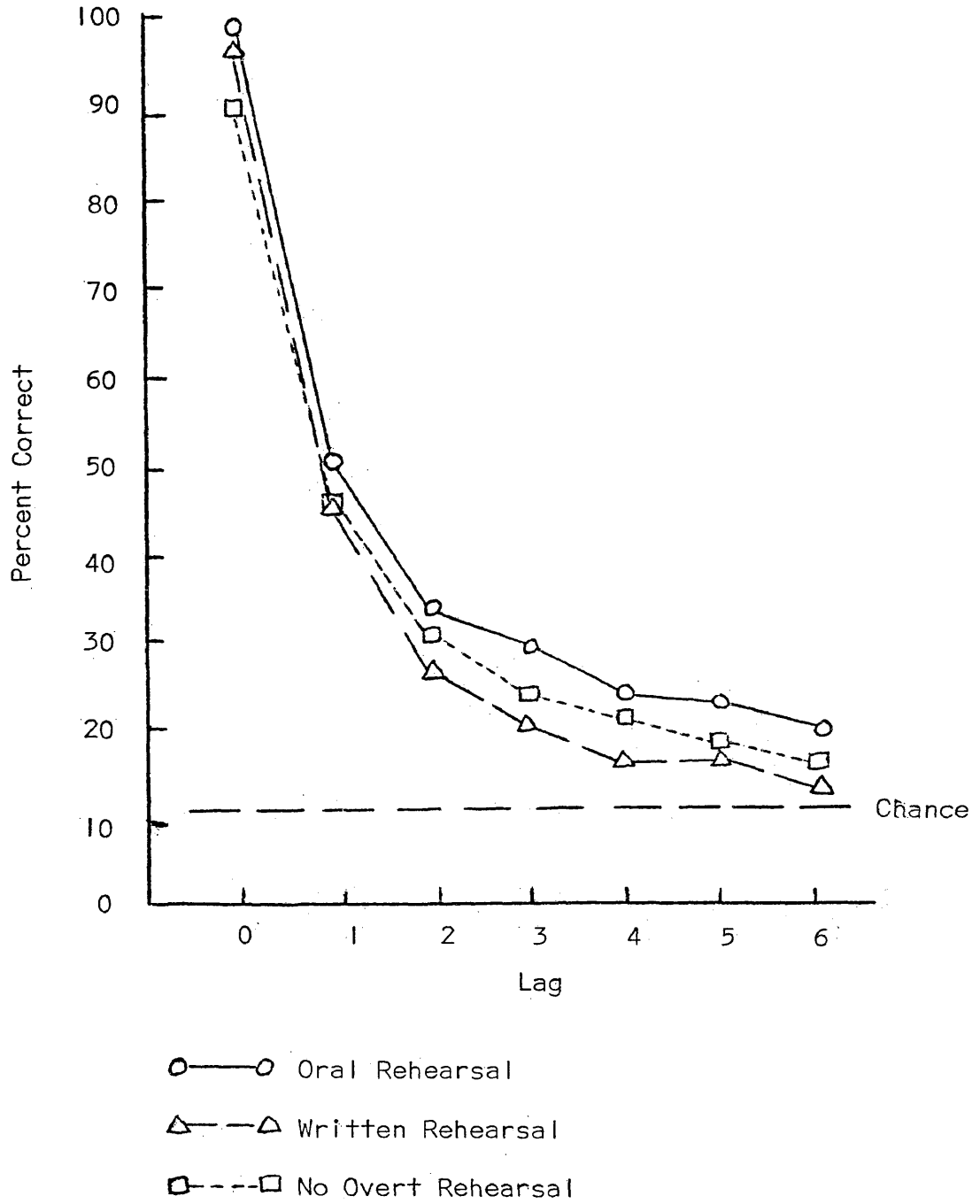
no overt rehearsal group. With greater lags performance continued to be best after oral rehearsal, and no overt rehearsal performance was better than after written rehearsal. Through lag five, mean performance was significantly greater than chance ($p < .001$). After six lags recall after written rehearsal was not significantly different from chance ($t_{39}=1.001$); mean recall was only 12.408, or a mean of one correct response per S. Recall after no overt rehearsal was 16.759, and was slightly better than chance ($t_{39}=2.518$, $p < .05$). Mean recall after oral rehearsal was 19.260, which was almost two correct responses per S; this was significantly greater than chance ($t_{39}=3.711$, $p < .001$).

Oral presentation resulted in significantly better recall than visual presentation. As shown in Figure 2, there was a decrease over lag for both methods of presentation, but recall of orally presented items was superior to that of visual items at every lag. Recall after oral presentation tended to be better than after visual presentation for all rehearsal conditions and with both types of recall.

Effects of mode of output were significant only in interaction with presentation modality and lag, shown in Figure 3. A test for critical differences between means was performed on the interaction data. Results are given in Table 5; subscripts are A_1 and A_2 for oral and visual presentation, B_1 and B_2 for spoken and written recall, and D_1 through D_7 for lags zero to six, respectively.

FIGURE 2

MEAN PERCENT OF CORRECT RESPONSES AFTER

VISUAL AND ORAL PRESENTATION
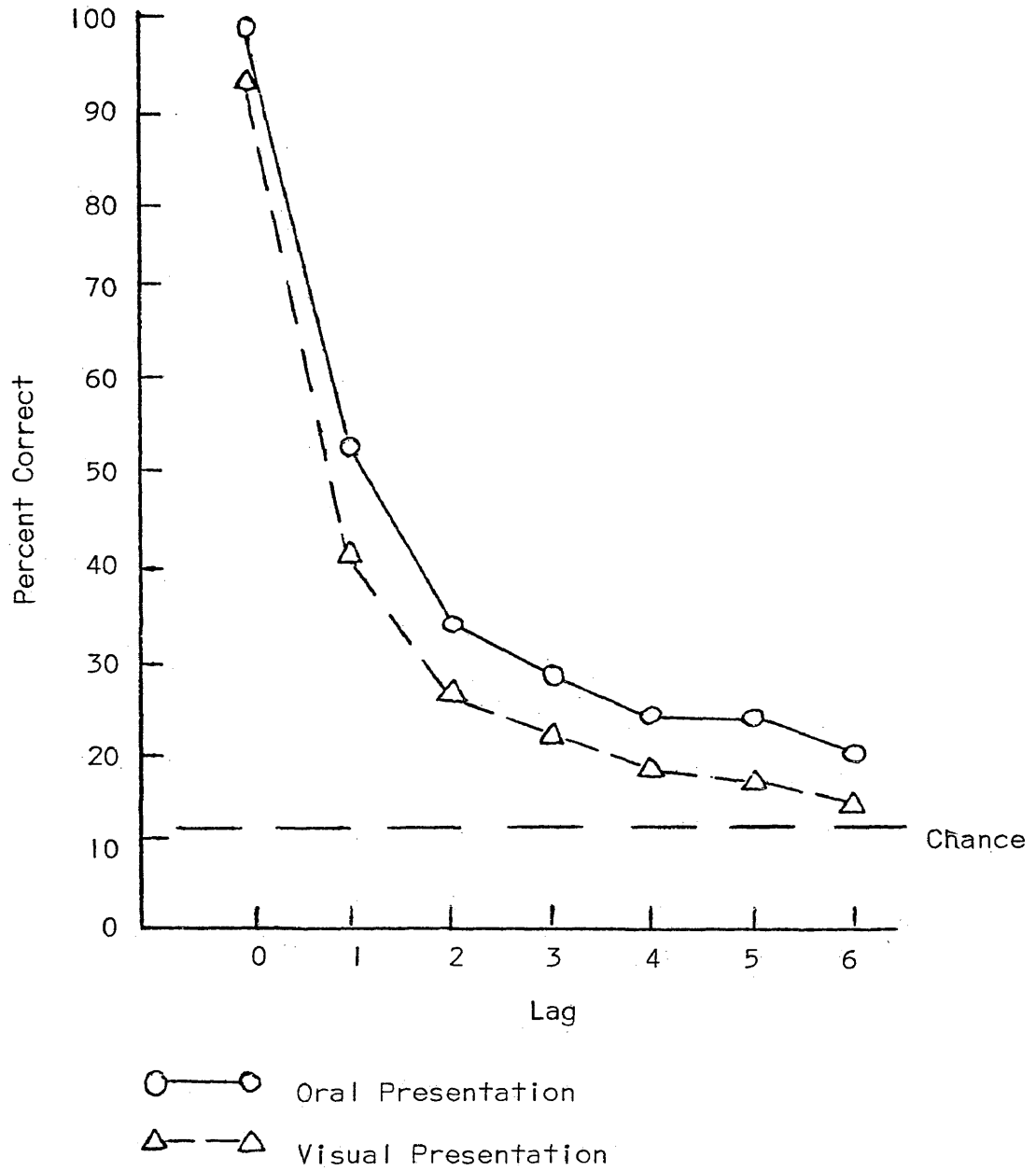
FIGURE 3

INTERACTION OF PRESENTATION MODALITY,

MODE OF OUTPUT, AND LAG

O————O Oral Presentation, Spoken Recall

●————● Oral Presentation, Written Recall

△——△ Visual Presentation, Spoken Recall

▲———▲ Visual Presentation, Written Recall
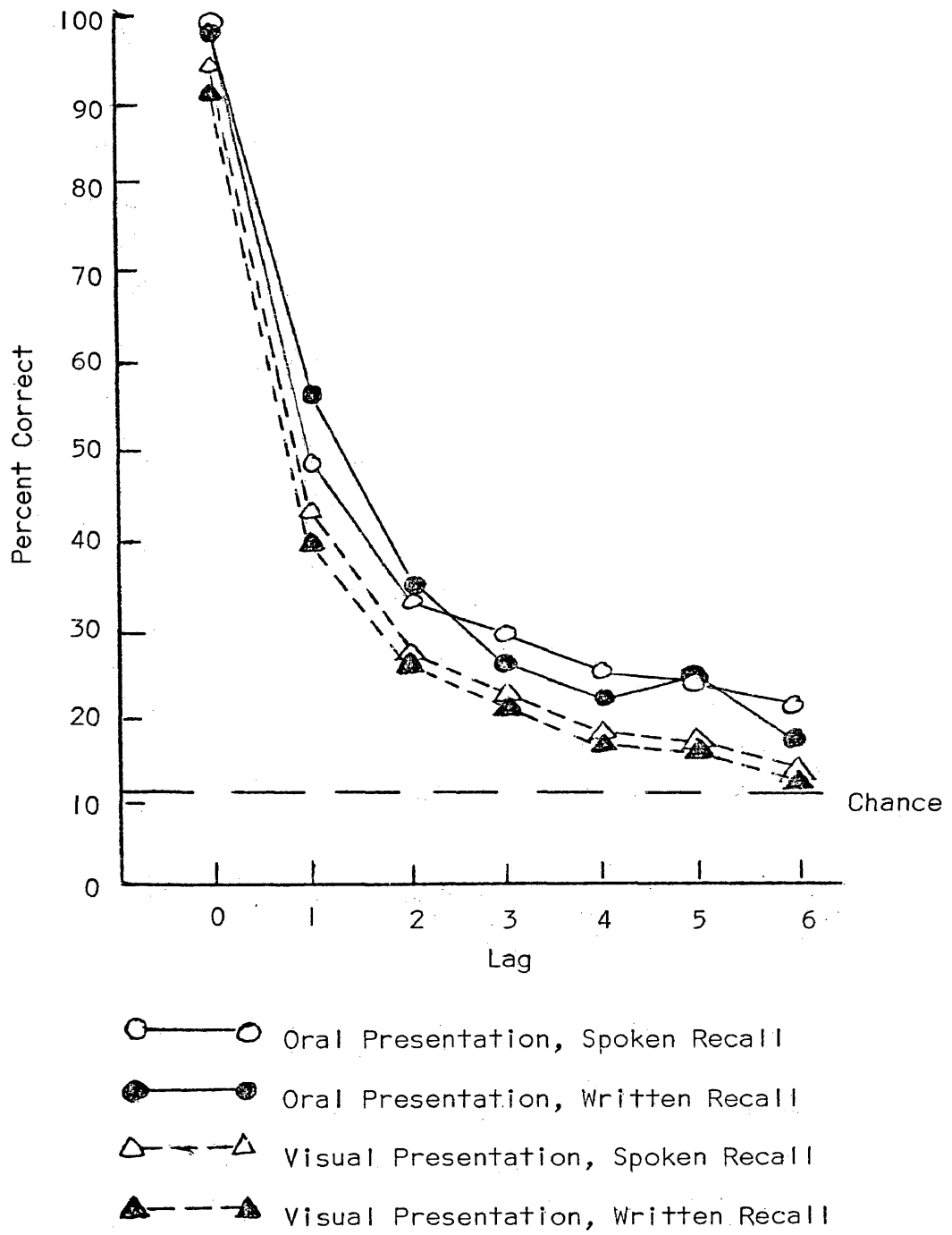
TABLE 5

DIFFERENCE BETWEEN MEANS FOR INTERACTION OF

PRESENTATION METHOD (A) x OUTPUT MODALITY (B) x LAG (D)

ABD Subscripts	111	112	113	Compared With 114	115	116	117
111	–	50.234**	65.895**	69.704**	73.752**	75.407**	78.025**
112		–	15.661**	19.470**	23.518**	25.173**	27.791**
113			–	3.809	7.857**	9.512**	12.130**
114				–	4.048	5.703*	8.321**
115					–	1.655	4.273
116						–	2.618
117							–

* p < .05

** p < .001

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Table 5, Continued

ABD Subscripts	121	122	123	124	125	126	127
111	0.370	41.958**	63.752**	73.038**	76.490**	75.406**	81.605**
112	49.864**	8.276**	13.518**	22.804**	26.256**	25.172**	31.371**
113	65.525**	23.937**	2.143	7.143*	10.595**	9.511**	15.710**
114	69.334**	27.746**	5.952*	3.334	6.786*	5.702*	11.901**
115	73.382**	31.794**	10.000**	0.714	2.738	1.654	7.853**
116	75.037**	33.449**	11.655**	2.369	1.083	0.001	6.198*
117	77.655**	36.067**	14.273**	4.987*	1.535	2.619	3.580
121	–	41.588**	63.382**	72.668**	76.120**	75.036**	81.235**
122		–	21.794**	31.080**	34.532**	33.448**	39.647**
123			–	9.286**	12.238**	11.654**	17.853**
124				–	4.452	2.368	8.567**
125					–	1.084	5.115*
126						–	6.100*
127							–

Table 5, Continued

ABD Subscripts	211	212	213	214	215	216	217
111	4.197	55.407**	71.728**	76.728**	81.014**	82.763**	84.197**
112	46.037**	5.173*	21.494**	26.494**	30.780**	32.529**	33.963**
113	61.698**	10.488**	5.833*	10.833**	15.119**	16.868**	18.302**
114	65.507**	14.297**	2.024	7.024*	11.310**	13.059**	14.493**
115	69.555**	46.037**	2.024	2.976	7.262*	9.011**	10.445**
116	71.210**	20.000**	3.679	1.321	5.607*	7.356*	8.790**
117	77.828**	22.618**	6.297*	1.297	2.989	4.738*	6.172*
121	3.827	55.037**	71.358**	76.358**	80.644**	82.393**	83.827**
122	37.761**	13.449**	29.770**	34.770**	39.056**	40.805**	42.239**
123	59.555**	8.345**	7.976**	12.976**	17.262**	19.011**	20.445**
124	68.841**	17.631**	1.310	3.690	7.976**	9.725**	11.159**
125	72.293**	21.083**	4.762*	0.238	4.524	6.273*	7.707*
126	71.209**	19.999**	3.678	1.322	5.608*	7.357*	8.791**
127	77.408**	26.198**	9.877**	4.877*	0.591	1.158	2.592
211	–	51.210**	67.531**	72.531**	76.817**	78.566**	80.000**
212		–	16.321**	21.321**	25.607**	27.356**	28.790**
213			–	5.000*	9.286**	11.035**	12.469**
214				–	4.286	6.035*	7.469*
215					–	1.749	3.183
216						–	1.434
217							–

ABD Subscripts	221	222	223	224	225	226	227
111	7.037*	58.510**	72.561**	77.085**	81.490**	82.878**	85.185**
112	43.197**	8.276**	22.327**	26.851**	31.256**	32.644**	34.951**
113	58.858**	7.385*	6.666*	11.190**	15.595**	16.983**	19.290**
114	62.667**	11.194**	2.857	7.381*	11.786**	13.174**	15.481**
115	66.715**	15.242**	1.191	3.333	7.738*	9.126**	11.433**
116	68.370**	6.897*	2.846	1.678	6.083*	7.471*	9.778**
117	70.988**	19.515**	5.464*	0.940	3.465	4.853*	7.160*
121	6.667*	58.140**	72.191**	76.715**	81.120**	82.508**	84.815**
122	34.921**	16.552**	30.603**	35.127**	39.532**	40.920**	43.227**
123	56.715**	5.242*	8.809**	13.333**	17.738**	19.126**	21.433**
124	66.001**	14.528**	0.477	4.047	8.452**	9.840**	12.147**
125	69.453**	17.980**	3.929	0.595	5.000*	6.388*	8.695**
126	68.369**	16.896**	2.845	1.679	6.084*	7.472*	9.779**
127	74.568**	23.095**	9.044**	4.520	0.115	1.273	3.580
211	2.840	54.313**	68.364**	72.888**	77.293**	78.681**	80.988**
212	48.370**	3.103	17.154**	21.678**	26.083**	27.471**	29.778**
213	64.691**	13.218**	0.833	5.357*	9.762**	11.150**	13.457**
214	69.691**	18.218**	4.167	0.357	4.762*	6.150*	8.457**
215	73.977**	22.504**	8.453**	3.929	0.476	1.864	4.171
216	75.726**	24.253**	10.202**	5.678*	1.273	0.115	2.422
217	77.160**	25.687**	11.636**	7.112*	2.707	0.319	0.988
221	–	51.473**	65.524**	70.048**	74.453**	75.841**	78.148**
222		–	14.051**	18.575**	22.980**	24.368**	26.675**
223			–	4.524	8.929**	10.317**	12.624**
224				–	4.405	5.793*	8.100**
225					–	1.388	3.695
226						–	2.307
227							–

DISCUSSION

Lag

Performance decreased over lag, or number of intervening trials. This result was expected since recall decreases as a function of amount of intervening material, and the continuous presentation method maximized interference. In this study there was also some additional interference by the interpolated task of counting numbers. Brelsford and Atkinson (1968) found that after six lags the mean proportion of correct responses was about four-tenths for both overt and covert rehearsal. Since the percent of correct responses was much less in the present study, it can be assumed that the intervening tasks of counting digits and saying the alphabet at least partially limited rehearsal in other modalities.

Input-Output Modality

Recall was better after oral presentation than after visual presentation at all lags, after all types of rehearsal, and with both types of recall. Since rehearsal insured that oral and visual items were both attended to, modality differences could not have been due to differences in attention. The findings support theories by Hintzman (1967) and Sperling (1967), which require visual information to be recoded into an auditory store. During the process of recoding visual items there is more opportunity for trace decay or for an item to be confused with others, than with the direct coding of orally presented information.

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The mode of output interacted with the presentation modality, as shown in Figure 3 and Table 5. There were differences between performance after the two presentation methods for each recall method. Oral recall of orally presented items was significantly better than oral recall of visually presented items at every lag except a lag of zero, where differences were not significant. With written recall, recall of orally presented items was significantly superior to recall of visually presented items for all lags except three and six.

Within each method of presentation there was little difference between written and spoken recall. With oral presentation written recall was better than spoken recall after a lag of one. With visual presentation there was no difference between written and spoken recall at any lag. Since mode of output had no effect except in interaction with presentation method, and gave similar performance for each presentation method, it was not a critical factor in recall. Method of presentation caused the modality differences in recall, for both modes of output.

Rehearsal

Oral rehearsal of visual and of oral lists resulted in significantly better recall than no overt rehearsal. This study did not find the S-shaped curve with oral rehearsal, as Breisford and Atkinson (1968) did; however, Breisford and Atkinson did not include the writing task which accompanied oral rehearsal in the present experiment. Performance after both types of rehearsal and after no overt rehearsal,decreased over lag in similarly shaped curves, as shown in Figure I. The written rehearsal curve had the greatest slope and mean performance reached chance of one correct response at a lag of six. No overt rehearsal curve was approaching chance

at lag six, but was still significantly different from it. The oral rehearsal curve was well above chance at lag six, with mean performance of nearly two correct responses.

Written rehearsal did not increase recall, and tended to result in poorer recall than after no overt rehearsal, for all lags except lag zero. Written rehearsal insured that Ss attended to the stimuli as well as they did for oral rehearsal. Since recall after written rehearsal was not as good as recall after oral rehearsal, and was not better than recall after no overt rehearsal, attention was not the critical variable.

The results suggest that modality of rehearsal, rather than extent of rehearsal, caused the recall differences. If information is stored orally, oral rehearsal, rather than written rehearsal, would facilitate memory. When information was presented visually, then rehearsed orally, S would immediately recode the visual stimulus to an oral one and begin rehearsing; the oral rehearsal strengthened the item in auditory storage. When items were presented orally, oral rehearsal also strengthened the item in an auditory store. Since there were no significant differences between written rehearsal and no overt rehearsal, it may be hypothesized that when rehearsal is not oral, the kind of rehearsal does not matter.

Summary

Memory was measured by the percent of items correctly recalled. Performance decreased over lags, as more trials intervened. Recall of oral items was significantly better than recall of visually presented items. The two modes of output differed only as a result of presentation modality. This indicated that modality differences were due to storage differences, and supported the models of Hintzman (1967) and Sperling (1967).

Oral rehearsal was superior to both written rehearsal and no overt rehearsal. Oral rehearsal improved recall by strengthening the item in auditory storage. There was no significant difference between overall recall after written rehearsal and after no overt rehearsal, indicating that written rehearsal does not improve recall. Since written rehearsal did not increase recall, the attention insured by overt rehearsal was not the critical variable. Modality, rather than attention, caused differences in recall.

APPENDIX A

INSTRUCTIONS

FOR CONDITIONS WITH VISUAL PRESENTATION

(Note: Each $\underline{S}$ was given the general instructions for visual presen-
tation plus instructions for the particular group he was in)

INSTRUCTIONS FOR ALL CONDITIONS WITH VISUAL PRESENTATION

This is a memory task. You will be presented a long list of stimulus-response pairs; that is, a two digit number paired with a letter of the alphabet. The first part of the pair will always be a two-digit number. In this case there'll be four of them--33, 44, 55, and 66. They'll be presented in random order with a letter of the alphabet. For example, pairs might be 33-J, 44-E, 55-X, 66-H.

You must remember the most recent letter paired with each number. Each trial will include a test--when you recall the letter most recently paired with the given number. You can then forget that letter and you will be given a new letter to remember for that same number. For example, you may have been given the pair 88-G. Later a test will be "88". You recall the response "G". Then you'll see a new letter paired with 88, such as "88-J". You'll now remember the 88-J pair and can forget the previous pair 88-G.

The procedure of the list will be alternating test and study periods. Suppose you have been presented these pairs: 33-H, 44-D, 55-C, 66-J. The list would go:

    "Test 55"   You respond "C"

    "Study 55-A"

    "Test 66"   You respond "J"

    "Study 66-F"

    "Test 33"   You respond "H"

"Study 33-E"

"Test 55"   You respond "A" since that was the most recent letter

paired with 55.

The list is filmed and will be projected on the wall. The word

"Study" precedes the number-letter pair you are to remember. The word

"Test" precedes the test number. These words are on the film but I'll

also say them aloud so you won't miss looking up to see the number-

letter pair.

ADDITIONAL INSTRUCTIONS

I Spoken Recall

After the word "Test" is given I'll say the test number. When you

hear the test number, say aloud the letter most recently paired with

it. Do not repeat the test number, just say the letter response. There

is only a short interval so say the letter as soon as you hear the test

number. This is a hard task and sometimes you may not remember the

letter at all. When this happens, just say nothing after the test.

If you think you know the answer, but aren't sure, go ahead and say

your hunch. But don't make wild guesses.

II Written Recall

When you see the test number, write down the letter most recently

paired with it on the numbered answer sheet. Do not write the test

number, only the letter response. There is only a short interval to

do this, so write the letter as soon as you see the test number.

This is a hard task and sometimes you may not remember the letter at

all. When this happens, just put a dash in the numbered space provided
for that letter. If you think you know the answer, but aren't sure,
go ahead and write your hunch. But don't make wild guesses. Be sure
not to skip any spaces on the answer sheet; always put the letter
answer or a dash.

III Oral Rehearsal

During the three second study period, you'll say aloud the stimulus-
response pair. If you see "Study 44-J", then say aloud "44-J, 44-J,..."
Keep repeating it for the entire period, until you see "Test". Do not
whisper or murmur; speak as loud as you would in conversation.

At the same time you'll write down digits 1, 2, 3, 4, etc. We'll
practice this so you can get used to doing the two things at once.

IV Written Rehearsal

During the three second study period, you'll write down the
stimulus-response pair. If you see "Study 44-J", then write down
"44-J, 44-J, ..." Keep repeating it for the entire period, until you
see "Test". As you see "Test" cover your writing with the cover sheet.

At the same time you'll say aloud digits 1, 2, 3, 4, etc. Do
not whisper or murmur; say the digits as loud as you would in conver-
sation. We'll practice this so you can get used to doing the two
things at once.

V No Overt Rehearsal

During the three second study period, you'll engage in two simple
tasks. You will be writing down digits 1, 2, 3, 4, 5, etc. At the
same time you'll say aloud the alphabet. Do not whisper or murmur;

speak as loud as you would in conversation. Keep writing digits and saying the alphabet during the entire study period, until you see "Test". We'll practice this so you can get used to doing the two things at once.

VI Summary of Sequence

   To summarize, the series will go like this:

A. You see "Study 44-J"

B. Immediately begin to say "44-J, 44-J, 44-J, ..." while writing

   "1, 2, 3, 4, 5, ..."

C. Immediately begin to write down "44-J, 44-J, 44-J, ..." while

   saying "1, 2, 3, 4, 5, ..."

D. Immediately begin to write down "1, 2, 3, 4, 5, ..." while saying

   "A, B, C, D, ..."

E. Cover your practice sheet of paper as you see "Test"

F. You see "Test"

G. I'll say "44" (or some other number)

H. You say aloud "J" (or the appropriate letter)

I. You see "Test 44" (or some other number)

J. You write down "J" (or the appropriate letter) on your answer sheet.

K. Steps 1 - 4 repeat with different number-letter pairs.

L. Steps 1 - 5 repeat with different number-letter pairs.

VII General Directions

   There will be two long lists; we'll do one then take a break before doing the other. Be sure you understand the procedure before we begin.

VIII Written Recall of Second List

The second list will be similar to the first except you'll see the test number on film instead of hearing it.

Another difference will be that you'll write down your answer instead of saying it aloud. You'll write it on a numbered answer sheet. Do not write the test number, only the letter response. If you don't remember the letter, just put a dash in the numbered space provided for that letter. Be sure not to skip any spaces on the answer sheet; always put the letter answer or a dash.

IX Spoken Recall of Second List

The second list will be similar to the first except I'll say the test number instead of you seeing it on film. The study part will still be shown on the film.

Another difference will be that you'll say aloud your answer instead of writing it down. When you hear the test number, say your letter answer. If you don't remember, just say nothing.

INSTRUCTIONS FOR EACH GROUP

Oral Rehearsal with Spoken Recall of the First List:

I; III; VI with statements A, B, F, G, H, L; VII; and VIII.

Oral Rehearsal with Written Recall of the First List:

II, III, VI with statements A, B, I, J, K; VII; and IX.

Written Rehearsal with Spoken Recall of the First List:

I; IV; VI with statements A, C, E, G, H, L; VII; and VIII.

Written Rehearsal with Written Recall of the First List:

II; IV; VI with statements A, C, E, I, J, L; VII; and IX.

No Overt Rehearsal with Spoken Recall of the First List:

I; V; VI with statements A. D. F. G. H. L; VII; and VIII.

No Overt Rehearsal with Written Recall of the First List:

II; V; VI with statements A, D, I, J, K; VII; and IX.

APPENDIX B

INSTRUCTIONS

FOR CONDITIONS WITH ORAL PRESENTATION

(Note: Each $\underline{S}$ was given the general instructions for oral presen-
tation plus instructions for the particular group he was in)

INSTRUCTIONS FOR ALL CONDITIONS WITH ORAL PRESENTATION

This is a memory task. You will be presented a long list of stimulus-response pairs; that is, a two digit number paired with a letter of the alphabet. The first part of the pair will always be a two-digit number. In this case there'll be four of them--33, 44, 55, and 66. They'll be presented in random order with a letter of the alphabet. For example, pairs might be 33-J, 44-E, 55-X, 66-H.

You must remember the most recent letter paired with each number. Each trial will include a test--when you recall the letter most recently paired with the given number. You can then forget that letter and you will be given a new letter to remember for that same number. For example, you may have heard the pair 88-G. Later a test will be "88". You recall the response "G". Then you'll hear a new letter paired with 88, such as "88-J". You'll now remember the 88-J pair and can forget the previous pair 88-G.

The procedure of the list will be alternating test and study periods. Suppose you have been presented these pairs: 33-H, 44-D, 55-C, 66-J. The list would go:

"Test 55"   You respond "C"

"Study 55-A"

"Test 66"   You respond "J"

"Study 66-F"

"Test 33"   You respond "H"

"Study 33-E"

"Test 55"   You respond "A" since that was the most recent letter

paired with 55.

The list is tape recorded and you will listen to it. The word

"Study" precedes the number-letter pair you are to remember. The word

"Test" precedes the test number.

ADDITIONAL INSTRUCTIONS

I   Spoken Recall

When you hear the test number, say aloud the letter most recently

paired with it. Do not repeat the test number, just say the letter

response. There is only a short interval to do this, so say the letter

as soon as you hear the test number. This is a hard task and some-

times you may not remember the letter at all. When this happens, just

say nothing after the test. If you think you know the answer but

aren't sure, go ahead and say your hunch. But don't make wild guesses.

II   Written Recall

After you hear the word "Test", I'll show you the test number on

a card. You write down the letter most recently paired with it on the

numbered answer sheet. Do not write the test number, only the letter

response. There is only a short interval to do this, so write the

letter as soon as you see the test number. This is a hard task and

sometimes you may not remember the letter at all. When this happens,

just put a dash in the numbered space provided for that letter. If

you think you know the answer, but aren't sure, go ahead and write

your hunch. But don't make wild guesses. Be sure not to skip any spaces on the answer sheet; always put the letter answer or a dash.

III   Oral Rehearsal

During the three second study period you'll say aloud the stimulus-response pair. If you hear "Study 44-J", then say aloud "44-J, 44-J,..." Keep repeating it for the entire period, until you hear "Test". Do not whisper or murmur; speak as loud as you would in conversation.

At the same time you'll write down digits 1, 2, 3, 4, etc. We'll practice this so you can get used to doing the two things at once.

IV   Written Rehearsal

During the three second study period you'll write down the stimulus-response pair. If you hear "Study 44-J" then write down "44-J, 44-J,..." Keep repeating it for the entire period, until you hear "Test". As you hear "Test" cover your writing with the cover sheet.

At the same time you'll say aloud digits 1, 2, 3, 4, etc. Do not whisper or murmur; say the digits as loud as you would in conversation. We'll practice this so you can get used to doing the two things at once.

V   No Overt Rehearsal

During the three second study period, you'll engage in two simple tasks. You will be writing digits 1, 2, 3, 4, 5, etc. At the same time you'll say aloud the alphabet. Do not whisper or murmur; speak as loud as you would in conversation. Keep writing digits and saying the alphabet during the entire study period, until you hear "Test". We'll practice this so you can get used to doing the two things at once.

VI   Summary of Sequence

To summarize, the series will go like this:

A.   You hear "Study 44-J"

B.   Immediately begin to say "44-J, 44-J, 44-J, ..." while writing

"1, 2, 3, 4, 5, ..."

C.   Immediately begin to write down "44-J, 44-J, 44-J, ..." while

saying "1, 2, 3, 4, 5, ..."

D.   Immediately begin to write down "1, 2, 3, 4, 5, ..." while

saying "A, B, C, D, ..."

E.   Cover your sheet of paper as you hear "Test"

F.   You hear "Test 44" (or some other number)

G.   You say aloud "J" (or the appropriate letter)

H.   You hear "Test"

I.   I'll show you the test number "44" (or some other number) on a card.

J.   You write down "J" (or the appropriate number) on your answer sheet.

K.   Steps 1 - 4 repeat with different number-letter pairs.

L.   Steps 1 - 5 repeat with different number-letter pairs.

VII   General Directions

There will be two long lists; we'll do one then take a break before

doing the other. Be sure you understand the procedure before we begin.

VIII   Written Recall of the Second List

The second list will be similar to the first except I'll show you

the test number on a card instead of you hearing it from the tape

recorder. The study part will still be given from the tape recorder.

Another difference will be that you'll write down your answer

instead of saying it aloud. You'll write it on a numbered answer

sheet. Do not write the test number, only the letter response. If you don't remember the letter, just put a dash in the numbered space provided for that letter. Be sure not to skip any spaces on the answer sheet; always put the letter answer or a dash.

IX Spoken Recall of the Second List

The second list will be similar to the first except you'll hear the test number from the tape recorder instead of seeing it on the card.

Another difference will be that you'll say aloud your answer instead of writing it down. When you hear the test number, say your letter answer. If you don't remember, just say nothing.

INSTRUCTIONS FOR EACH GROUP

Oral Rehearsal with Spoken Recall of the First List:

   I; III; VI with statements A, B, F, G, K; VII; and VIII.

Oral Rehearsal with Written Recall of the First List:

   II; III; VI with statements A, B, H, I, J, L; VII; and IX.

Written Rehearsal with Spoken Recall of the First List:

   I; IV; VI with statements A, C, E, F, G, L; VII; and VIII.

Written Rehearsal with Written Recall of the First List:

   II; IV; VI with statements A, C, E, I, J, L; VII; and IX.

No Overt Rehearsal with Spoken Recall of the First List:

   I; V; VI with statements A, D, F, G, K; VII; and VIII.

No Overt Rehearsal with Written Recall of the First List:

   II; V; VI with statements A, D, H, I, J, L; VII; and IX.

APPENDIX C

STIMULUS-RESPONSE LISTS

PRACTICE LIST

STUDY 44-N	TEST 44	TEST 33	TEST 55
STUDY 55-S	STUDY 44-T	STUDY 33-R	STUDY 55-Y
STUDY 33-Y	TEST 66	TEST 44	TEST 66
STUDY 66-K	STUDY 66-U	STUDY 44-K	STUDY 66-T
TEST 55	TEST 66	TEST 33	TEST 55
STUDY 55-O	STUDY 66-L	STUDY 33-N	

LIST A

STUDY 55-S	TEST 66	TEST 66	TEST 33	TEST 66
STUDY 33-O	STUDY 66-S	STUDY 66-L	STUDY 33-U	STUDY 66-K
STUDY 44-U	TEST 55	TEST 44	TEST 66	TEST 44
STUDY 66-N	STUDY 55-O	STUDY 44-S	STUDY 66-R	STUDY 44-U
TEST 44	TEST 44	TEST 66	TEST 33	TEST 33
STUDY 44-K	STUDY 44-T	STUDY 66-Y	STUDY 33-L	STUDY 33-O
TEST 55	TEST 55	TEST 33	TEST 55	TEST 33
STUDY 55-R	STUDY 55-N	STUDY 33-T	STUDY 55-S	STUDY 33-L
TEST 66	TEST 44	TEST 44	TEST 44	TEST 55
STUDY 66-T	STUDY 44-K	STUDY 44-O	STUDY 44-Y	STUDY 55-R
TEST 33	TEST 33	TEST 44	TEST 55	TEST 55
STUDY 33-L	STUDY 33-R	STUDY 44-N	STUDY 55-T	STUDY 55-Y
TEST 33	TEST 55	TEST 55	TEST 66	TEST 44
STUDY 33-Y	STUDY 55-U	STUDY 55-K	STUDY 66-N	STUDY 44-T

TEST 66	TEST 66	TEST 66	TEST 44	TEST 33
STUDY 66-S	STUDY 66-S	STUDY 66-R	STUDY 44-S	STUDY 33-K
TEST 55	TEST 55	TEST 55	TEST 66	TEST 55
STUDY 55-K	STUDY 55-T	STUDY 55-N	STUDY 66-T	STUDY 55-L
TEST 44	TEST 44	TEST 66	TEST 44	TEST 66
STUDY 44-N	STUDY 44-L	STUDY 66-U	STUDY 44-R	STUDY 66-O
TEST 33	TEST 33	TEST 33	TEST 33	TEST 44
STUDY 33-U	STUDY 33-R	STUDY 33-S	STUDY 33-Y	STUDY 44-U
TEST 66	TEST 66	TEST 55	TEST 55	TEST 44
STUDY 66-T	STUDY 66-O	STUDY 55-L	STUDY 55-K	STUDY 44-R
TEST 55	TEST 66	TEST 44	TEST 55	TEST 55
STUDY 55-L	STUDY 66-Y	STUDY 44-Y	STUDY 55-O	STUDY 55-N
TEST 33	TEST 33	TEST 55	TEST 44	TEST 66
STUDY 33-S	STUDY 33-N	STUDY 55-R	STUDY 44-U	STUDY 66-Y
TEST 55	TEST 44	TEST 33	TEST 66	TEST 33
STUDY 55-O	STUDY 44-U	STUDY 33-T	STUDY 66-L	STUDY 33-S
TEST 33	TEST 55	TEST 33	TEST 66	TEST 66
STUDY 33-Y	STUDY 55-S	STUDY 33-N	STUDY 66-R	STUDY 66-O
TEST 44	TEST 33	TEST 66	TEST 44	TEST 55
STUDY 44-R	STUDY 33-K	STUDY 66-K	STUDY 44-N	STUDY 55-T
TEST 66	TEST 66	TEST 33	TEST 33	TEST 44
STUDY 66-U	STUDY 66-L	STUDY 33-O	STUDY 33-T	STUDY 44-L
TEST 33	TEST 44	TEST 55	TEST 44	TEST 66
STUDY 33-K	STUDY 44-T	STUDY 55-U	STUDY 44-S	STUDY 66-K
TEST 66	TEST 44	TEST 44	TEST 55	TEST 33
STUDY 66-N	STUDY 44-O	STUDY 44-L	STUDY 55-Y	STUDY 33-Y

TEST 33	TEST 55	TEST 55	TEST 55	TEST 55
STUDY 33-U	STUDY 55-U	STUDY 55-S	STUDY 55-T	STUDY 55-R
TEST 66	TEST 33	TEST 66	TEST 44	TEST 33
STUDY 66-N	STUDY 33-R	STUDY 66-K	STUDY 44-N	STUDY 33-S
TEST 44	TEST 44	TEST 66	TEST 66	TEST 66
STUDY 44-O	STUDY 44-S	STUDY 66-T	STUDY 66-R	STUDY 66-N
TEST 55	TEST 66	TEST 33	TEST 66	TEST 33
STUDY 55-S	STUDY 66-T	STUDY 33-O	STUDY 66-L	STUDY 33-L
TEST 55	TEST 33	TEST 44	TEST 44	TEST 55
STUDY 55-K	STUDY 33-L	STUDY 44-U	STUDY 44-K	STUDY 55-O
TEST 44	TEST 55	TEST 44	TEST 55	TEST 44
STUDY 44-R	STUDY 55-Y	STUDY 44-Y	STUDY 55-S	STUDY 44-U
TEST 33	TEST 55	TEST 55	TEST 33	TEST 33
STUDY 33-T	STUDY 55-N	STUDY 55-R	STUDY 33-Y	STUDY 33-R
TEST 66	TEST 66	TEST 33	TEST 33	TEST 55
STUDY 66-U	STUDY 66-U	STUDY 33-N	STUDY 33-O	STUDY 55-S
TEST 33	TEST 33	TEST 55	TEST 55	TEST 55
STUDY 33-L	STUDY 33-K	STUDY 55-L	STUDY 55-N	STUDY 55-Y
TEST 33	TEST 44	TEST 66	TEST 44	TEST 66
STUDY 33-N	STUDY 44-O	STUDY 66-S	STUDY 44-T	STUDY 66-T
TEST 55	TEST 33	TEST 44	TEST 66	TEST 33
STUDY 55-Y	STUDY 33-R	STUDY 44-O	STUDY 66-U	STUDY 33-K
TEST 66	TEST 44	TEST 55	TEST 44	TEST 44
STUDY 66-O	STUDY 44-L	STUDY 55-K	STUDY 44-Y	STUDY 44-L
TEST 44	TEST 66	TEST 33	TEST 66	TEST 55
STUDY 44-K	STUDY 66-Y	STUDY 33-U	STUDY 66-K	STUDY 55-O

TEST 66	TEST 44	TEST 55	TEST 44	TEST 66
STUDY 66-Y	STUDY 44-U	STUDY 55-O	STUDY 44-K	STUDY 66-O
TEST 44	TEST 33	TEST 33	TEST 66	TEST 44
STUDY 44-S	STUDY 33-S	STUDY 33-U	STUDY 66-R	STUDY 44-L
TEST 44	TEST 33	TEST 55	TEST 33	TEST 55
STUDY 44-N	STUDY 33-O	STUDY 55-Y	STUDY 33-S	STUDY 55-S
TEST 33	TEST 55	TEST 44	TEST 66	TEST 33
STUDY 33-T	STUDY 55-T	STUDY 44-S	STUDY 66-Y	STUDY 33-K
TEST 66	TEST 44	TEST 66	TEST 55	TEST 66
STUDY 66-R	STUDY 44-R	STUDY 66-T	STUDY 55-T	
TEST 55	TEST 66	TEST 33	TEST 33	
STUDY 55-L	STUDY 66-K	STUDY 33-O	STUDY 33-U	
TEST 44	TEST 66	TEST 55	TEST 44	
STUDY 44-K	STUDY 66-L	STUDY 55-U	STUDY 44-N	
TEST 66	TEST 33	TEST 55	TEST 44	
STUDY 66-N	STUDY 33-N	STUDY 55-L	STUDY 44-R	

LIST B

STUDY 33-O	TEST 44	TEST 33	TEST 66	TEST 44
STUDY 66-S	STUDY 44-N	STUDY 33-S	STUDY 66-R	STUDY 44-K
STUDY 55-L	TEST 66	TEST 55	TEST 33	TEST 66
STUDY 44-T	STUDY 66-U	STUDY 55-N	STUDY 33-L	STUDY 66-N
TEST 55	TEST 66	TEST 33	TEST 44	TEST 55
STUDY 55-Y	STUDY 66-K	STUDY 33-T	STUDY 44-U	STUDY 55-S
TEST 33	TEST 44	TEST 55	TEST 55	TEST 55
STUDY 33-R	STUDY 44-O	STUDY 55-Y	STUDY 55-O	STUDY 55-T

TEST 33	TEST 33	TEST 66	TEST 55	TEST 33
STUDY 33-Y	STUDY 33-K	STUDY 66-Y	STUDY 55-N	STUDY 33-L
TEST 66	TEST 55	TEST 44	TEST 55	TEST 55
STUDY 66-L	STUDY 55-N	STUDY 44-T	STUDY 55-S	STUDY 55-U
TEST 44	TEST 44	TEST 44	TEST 44	TEST 55
STUDY 44-R	STUDY 44-O	STUDY 44-O	STUDY 44-R	STUDY 55-O
TEST 66	TEST 33	TEST 33	TEST 33	TEST 44
STUDY 66-U	STUDY 33-Y	STUDY 33-N	STUDY 33-T	STUDY 44-N
TEST 33	TEST 55	TEST 55	TEST 44	TEST 55
STUDY 33-O	STUDY 55-T	STUDY 55-U	STUDY 44-L	STUDY 55-R
TEST 55	TEST 66	TEST 66	TEST 66	TEST 66
STUDY 55-K	STUDY 66-L	STUDY 66-R	STUDY 66-O	STUDY 66-K
TEST 33	TEST 44	TEST 44	TEST 33	TEST 33
STUDY 33-N	STUDY 44-N	STUDY 44-S	STUDY 33-U	STUDY 33-Y
TEST 44	TEST 33	TEST 44	TEST 55	TEST 33
STUDY 44-T	STUDY 33-U	STUDY 44-K	STUDY 55-K	STUDY 33-S
TEST 44	TEST 66	TEST 66	TEST 33	TEST 55
STUDY 44-Y	STUDY 66-O	STUDY 66-T	STUDY 33-R	STUDY 55-L
TEST 55	TEST 33	TEST 55	TEST 66	TEST 44
STUDY 55-L	STUDY 33-S	STUDY 55-L	STUDY 66-N	STUDY 44-U
TEST 66	TEST 66	TEST 33	TEST 66	TEST 44
STUDY 66-S	STUDY 66-K	STUDY 33-O	STUDY 66-T	STUDY 44-R
TEST 66	TEST 55	TEST 66	TEST 44	TEST 55
STUDY 66-U	STUDY 55-R	STUDY 66-Y	STUDY 44-Y	STUDY 55-T
TEST 33	TEST 44	TEST 44	TEST 66	TEST 66
STUDY 33-R	STUDY 44-L	STUDY 44-U	STUDY 66-S	STUDY 66-N

TEST 55	TEST 44	TEST 44	TEST 55	TEST 33
STUDY 55-O	STUDY 44-Y	STUDY 44-S	STUDY 55-U	STUDY 33-Y
TEST 33	TEST 66	TEST 55	TEST 44	TEST 66
STUDY 33-K	STUDY 66-K	STUDY 55-Y	STUDY 44-K	STUDY 66-L
TEST 66	TEST 66	TEST 33	TEST 33	TEST 33
STUDY 66-Y	STUDY 66-L	STUDY 33-L	STUDY 33-O	STUDY 33-N
TEST 33	TEST 44	TEST 66	TEST 44	TEST 55
STUDY 33-U	STUDY 44-T	STUDY 66-R	STUDY 44-Y	STUDY 55-T
TEST 44	TEST 55	TEST 55	TEST 44	TEST 44
STUDY 44-S	STUDY 55-S	STUDY 55-O	STUDY 44-N	STUDY 44-R
TEST 55	TEST 33	TEST 44	TEST 66	TEST 44
STUDY 55-L	STUDY 33-O	STUDY 44-N	STUDY 66-S	STUDY 44-U
TEST 55	TEST 33	TEST 66	TEST 55	TEST 55
STUDY 55-R	STUDY 33-Y	STUDY 66-U	STUDY 55-L	STUDY 55-Y
TEST 33	TEST 55	TEST 33	TEST 55	TEST 33
STUDY 33-T	STUDY 55-R	STUDY 33-K	STUDY 55-K	STUDY 33-O
TEST 44	TEST 66	TEST 33	TEST 33	TEST 66
STUDY 44-K	STUDY 66-N	STUDY 33-T	STUDY 33-R	STUDY 66-K
TEST 66	TEST 44	TEST 44	TEST 66	TEST 66
STUDY 66-O	STUDY 44-L	STUDY 44-L	STUDY 66-T	STUDY 66-S
TEST 44	TEST 66	TEST 66	TEST 33	TEST 33
STUDY 44-S	STUDY 66-U	STUDY 66-Y	STUDY 33-U	STUDY 33-T
TEST 33	TEST 66	TEST 55	TEST 44	TEST 55
STUDY 33-N	STUDY 66-T	STUDY 55-S	STUDY 44-O	STUDY 55-N
TEST 55	TEST 33	TEST 66	TEST 55	TEST 44
STUDY 55-U	STUDY 33-K	STUDY 66-R	STUDY 55-S	STUDY 44-L

TEST 55	TEST 44	TEST 44	TEST 33	TEST 66
STUDY 55-K	STUDY 44-N	STUDY 44-T	STUDY 33-K	STUDY 66-L
TEST 44	TEST 66	TEST 55	TEST 55	TEST 55
STUDY 44-Y	STUDY 66-Y	STUDY 55-L	STUDY 55-O	STUDY 55-T
TEST 33	TEST 55	TEST 66	TEST 44	TEST 55
STUDY 33-R	STUDY 55-U	STUDY 66-O	STUDY 44-N	STUDY 55-R
TEST 66	TEST 33	TEST 66	TEST 66	TEST 44
STUDY 66-O	STUDY 33-S	STUDY 66-S	STUDY 66-S	STUDY 44-S
TEST 44	TEST 44	TEST 33	TEST 33	TEST 55
STUDY 44-T	STUDY 44-K	STUDY 33-N	STUDY 33-L	STUDY 55-U
TEST 66	TEST 55	TEST 55	TEST 33	TEST 33
STUDY 66-U	STUDY 55-O	STUDY 55-R	STUDY 33-U	STUDY 33-O
TEST 33	TEST 55	TEST 44	TEST 55	TEST 66
STUDY 33-S	STUDY 55-T	STUDY 44-Y	STUDY 55-Y	STUDY 66-Y
TEST 55	TEST 66	TEST 44	TEST 44	TEST 44
STUDY 55-L	STUDY 66-N	STUDY 44-U	STUDY 44-R	
TEST 66	TEST 44	TEST 66	TEST 66	
STUDY 66-R	STUDY 44-R	STUDY 66-T	STUDY 66-O	
TEST 33	TEST 33	TEST 33	TEST 44	
STUDY 33-O	STUDY 33-U	STUDY 33-S	STUDY 44-K	
TEST 33	TEST 55	TEST 66	TEST 33	
STUDY 33-K	STUDY 55-Y	STUDY 66-L	STUDY 33-N	

APPENDIX D

Ss' INDIVIDUAL SCORES

PERCENT CORRECT FOR $\underline{Ss}$ WITH VISUAL PRESENTATION, ORAL REHEARSAL, AND SPOKEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	100.000	41.379	3.571	0.000	0.000	0.000	3.704
2	88.889	20.690	28.571	10.714	7.143	13.793	11.111
3	100.000	62.069	60.714	64.286	57.143	58.621	55.556
4	100.000	41.379	21.429	32.143	28.571	17.241	18.519
5	100.000	31.034	10.714	7.143	3.571	6.897	7.407
6	100.000	34.483	14.286	14.286	7.143	3.448	3.704
7	100.000	41.379	17.857	7.143	14.286	13.793	3.704
8	100.000	55.172	50.000	28.571	32.143	20.690	14.815
9	96.296	41.379	14.286	10.714	7.143	6.897	11.111
10	100.000	58.621	32.143	28.571	17.857	10.345	18.519

PERCENT CORRECT FOR Ss WITH VISUAL PRESENTATION, ORAL REHEARSAL, AND WRITTEN RECALL

S#	Lag						
	0	1	2	3	4	5	6
1	96.296	37.931	17.857	10.714	3.571	0.000	3.704
2	100.000	31.034	32.143	25.000	10.714	17.241	11.111
3	96.296	79.310	39.286	50.000	53.571	41.379	33.333
4	100.000	68.966	25.000	17.857	21.429	27.586	14.815
5	96.296	27.586	17.857	14.286	7.143	3.448	7.407
6	100.000	31.034	10.714	7.143	10.714	6.897	3.704
7	100.000	37.931	25.000	14.286	14.286	6.897	11.111
8	100.000	68.966	71.429	46.429	46.429	37.931	29.630
9	100.000	65.517	21.429	10.714	10.714	13.793	11.111
10	96.296	48.276	28.571	21.429	10.714	17.241	11.111

PERCENT CORRECT FOR Ss WITH VISUAL PRESENTATION, WRITTEN REHEARSAL, AND SPOKEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	100.000	34.483	14.286	25.000	7.143	10.345	0.000
2	92.593	31.034	0.000	3.571	3.571	10.345	0.000
3	96.296	44.827	14.286	3.571	3.571	17.421	14.815
4	96.296	75.862	67.857	46.429	21.429	20.690	7.407
5	88.889	55.172	32.143	35.714	21.429	17.241	18.519
6	96.296	37.931	25.000	7.143	14.286	24.138	11.111
7	100.000	44.827	25.000	21.429	14.286	17.241	14.815
8	96.296	48.276	28.571	25.000	10.714	20.690	14.815
9	100.000	34.483	17.857	17.857	7.143	13.793	11.111
10	100.000	37.931	25.000	17.857	10.714	10.345	3.704

PERCENT CORRECT FOR S̲s̲ WITH VISUAL PRESENTATION, WRITTEN REHEARSAL, AND WRITTEN RECALL

S#	\	\	\	Lag 3	\	\	\
	0	1	2	3	4	5	6
1	100.000	31.034	21.429	21.429	3.571	13.793	3.704
2	96.296	41.379	39.286	10.714	7.143	3.448	0.000
3	100.000	10.345	14.286	14.286	0.000	6.897	11.111
4	100.000	27.586	28.571	21.429	14.286	20.690	29.630
5	96.296	48.276	25.000	32.143	32.143	17.241	14.815
6	70.370	27.586	25.000	17.857	17.857	13.793	14.815
7	100.000	37.931	7.143	17.857	10.714	20.690	14.815
8	96.296	34.483	25.000	17.857	14.286	13.793	3.704
9	92.593	37.931	25.000	21.429	10.714	10.345	7.407
10	96.296	41.379	17.857	17.857	7.143	13.793	14.815

PERCENT CORRECT FOR Ss WITH VISUAL PRESENTATION, NO-OVERT REHEARSAL, AND SPOKEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	92.593	37.931	28.571	21.429	21.429	10.345	7.407
2	96.296	75.862	75.000	60.714	71.429	48.276	66.667
3	85.185	31.034	17.857	14.286	10.714	27.586	22.222
4	74.074	55.172	14.286	32.143	14.286	3.448	7.407
5	96.296	41.379	32.143	10.714	14.286	10.345	11.111
6	92.593	41.379	42.857	28.571	21.429	31.034	29.630
7	92.593	41.379	21.429	25.000	28.571	3.448	7.407
8	85.185	27.586	10.714	7.143	17.857	3.448	11.111
9	77.777	31.034	32.143	25.000	14.286	3.448	11.111
10	81.481	34.483	21.429	17.857	17.857	13.793	7.407

PERCENT CORRECT FOR Ss WITH VISUAL PRESENTATION, NO OVERT REHEARSAL, AND WRITTEN RECALL

S#				Lag			
	0	1	2	3	4	5	6
1	66.667	27.586	14.286	7.143	10.714	6.897	7.407
2	88.889	82.759	75.000	57.143	64.286	62.069	40.741
3	74.074	20.690	17.857	21.429	7.143	17.241	22.222
4	81.481	24.138	21.429	21.429	3.571	3.448	3.704
5	70.370	27.586	3.571	3.571	7.143	3.448	3.704
6	81.481	62.069	46.429	46.429	42.857	27.586	33.333
7	100.000	20.690	28.571	25.000	32.143	3.448	14.815
8	74.074	17.241	14.286	7.143	10.714	17.241	7.407
9	88.889	41.379	21.429	21.429	14.286	6.897	3.704
10	81.481	37.931	14.286	17.857	7.143	10.345	7.407

PERCENT CORRECT FOR S̲s̲ WITH ORAL PRESENTATION, ORAL REHEARSAL, AND SPOKEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	100.000	31.034	25.000	17.857	14.286	17.241	18.519
2	100.000	51.724	28.571	25.000	25.000	31.034	14.815
3	100.000	79.310	67.857	57.143	60.714	51.724	48.148
4	100.000	55.172	42.857	28.571	21.429	31.034	18.519
5	96.296	44.827	35.714	32.143	28.571	17.241	11.111
6	100.000	34.483	17.857	17.857	21.429	20.690	25.926
7	100.000	65.517	42.857	50.000	25.000	37.931	29.630
8	100.000	72.414	50.000	50.000	39.286	41.379	37.037
9	100.000	65.517	50.000	60.714	42.857	27.586	44.444
10	100.000	13.793	17.857	17.857	17.857	6.897	7.407

PERCENT CORRECT FOR Ss WITH ORAL PRESENTATION, ORAL REHEARSAL, AND WRITTEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	96.296	31.034	32.143	17.857	14.286	24.138	18.519
2	100.000	72.414	50.000	10.714	28.571	27.586	25.926
3	100.000	89.655	89.286	82.143	82.143	68.966	55.556
4	100.000	51.724	71.429	42.857	39.286	51.724	33.333
5	100.000	68.966	7.143	28.571	0.000	13.793	7.407
6	100.000	41.379	21.429	10.714	21.429	13.793	11.111
7	96.296	72.414	57.143	32.143	21.429	20.690	22.222
8	100.000	58.621	42.857	67.857	21.429	37.931	18.519
9	100.000	62.069	35.714	39.286	25.000	37.931	14.815
10	96.296	24.138	10.714	7.143	21.429	6.897	22.222

PERCENT CORRECT FOR Ss WITH ORAL PRESENTATION, WRITTEN REHEARSAL, AND SPOKEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	100.000	51.724	39.286	39.286	10.714	34.483	22.222
2	100.000	37.931	17.857	21.429	21.429	20.690	0.000
3	100.000	48.276	46.429	35.714	57.143	17.241	25.926
4	96.296	34.483	25.000	21.429	10.714	13.793	11.111
5	100.000	55.172	21.429	10.714	28.571	24.138	18.519
6	92.593	13.793	7.143	7.143	7.143	20.690	11.111
7	100.000	62.069	25.000	10.714	25.000	13.793	14.815
8	96.296	55.172	25.000	46.429	28.571	20.690	25.926
9	100.000	41.379	21.429	3.571	7.143	3.448	14.815
10	100.000	58.621	39.286	28.571	32.143	41.379	33.333

PERCENT CORRECT FOR Ss WITH ORAL PRESENTATION, WRITTEN REHEARSAL, AND WRITTEN RECALL

S#	Lag 0	1	2	3	4	5	6
1	100.000	72.414	39.286	28.571	21.429	20.690	18.519
2	100.000	62.029	35.714	32.143	14.286	6.897	11.111
3	100.000	62.029	32.143	10.714	10.714	17.241	11.111
4	100.000	55.172	25.000	21.429	21.429	17.241	18.519
5	100.000	68.966	25.000	25.000	10.714	10.345	18.519
6	100.000	20.690	17.857	14.286	17.857	24.138	7.407
7	100.000	58.621	32.143	21.429	10.714	6.897	3.704
8	100.000	55.172	35.714	25.000	28.571	24.138	0.000
9	100.000	31.034	32.143	7.143	14.286	13.793	11.111
10	100.000	72.414	28.571	17.857	25.000	27.586	7.407

PERCENT CORRECT FOR Ss WITH ORAL PRESENTATION, NO OVERT REHEARSAL, AND SPOKEN RECALL

S#	0	1	2	Lag 3	4	5	6
1	96.296	31.034	35.714	21.429	7.143	10.345	11.111
2	100.000	48.276	14.286	7.143	14.286	10.345	3.704
3	96.296	37.931	35.714	32.143	28.571	27.586	22.222
4	100.000	51.724	53.571	42.857	17.857	27.586	29.630
5	85.185	37.931	17.857	7.143	14.286	6.897	14.815
6	96.296	37.931	21.429	17.857	14.286	17.241	7.407
7	96.296	55.172	35.714	50.000	32.143	20.690	37.037
8	100.000	86.207	57.143	46.429	50.000	31.034	22.222
9	100.000	24.138	10.714	3.571	3.571	0.000	0.000
10	100.000	62.069	46.429	50.000	32.143	44.827	29.630

PERCENT CORRECT FOR Ss WITH ORAL PRESENTATION, NO OVERT REHEARSAL, AND WRITTEN RECALL

S#	0	1	2	3	4	5	6
1	96.296	65.517	25.000	10.714	7.143	13.793	0.000
2	96.296	48.276	14.286	17.857	10.714	10.345	3.704
3	96.296	68.966	57.143	14.286	10.714	13.793	18.519
4	96.296	72.414	46.429	39.286	35.714	34.483	18.519
5	92.593	58.621	57.143	57.143	50.000	48.276	44.444
6	92.593	41.379	14.286	10.714	17.857	10.345	7.407
7	96.296	58.621	32.143	17.857	21.429	24.138	18.519
8	92.593	55.172	21.429	17.857	25.000	24.138	14.815
9	96.296	27.586	10.714	3.571	7.143	10.345	7.407
10	96.296	65.517	39.286	28.571	21.429	27.586	33.333

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