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SOME EFFECTS OF LOCUS OF INFORMATION IN VISUAL DISPLAYS ON RETENTION

A THESIS

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By

Jeffrey Van Pulver

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SOME EFFECTS OF LOCUS OF INFORMATION IN VISUAL DISPLAYS ON RETENTION

Approved:

Dr. Philip J. Sieghmann, Chairman

Dr. Miroslav Valach

Mr. Alton P. Jensen

Date approved by Chairman: 4/7/77.
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SUMMARY

The effects of locus of information in visual displays on retention was studied in a dialog setting. Complete sets of stimulus and response items were displayed in a linear order for a paired-associate task. In the dialog setting subjects acquired and rehearsed information on predetermined stimulus and response pairs. The stimulus items chosen were numbers and the response items were letters.

The dialog procedure enabled the subjects to control the rate and sequence of information by asking questions about items presented in the visual display. Three types of questions were permitted, simple questions about single stimulus-response pairs, and conjunctive and disjunctive questions about multiple stimulus-response pairs. The paired-associate task consisted of 12 stimulus-response pairs and the criterion for acquisition was one errorless trial for all pairs. The subsequent retention task followed after a 24 hour interval. Three measures of retention were taken consisting of initial unaided recall, and two subsequent prompted recalls.

The hypothesis tested was based on an interpretation of the stimulus selection paradigm with the assumption that the serial position of the stimulus items in the visual display constituted a stimulus component and is encoded by subjects during acquisition. It was predicted a retention display which presents the stimulus items in the serial order identical to initial learning would constitute an effective prompt since it reinstated the locus of serial order encoded
during acquisition. Retention displays presenting only response items in original order however constituted a less effective prompt.

Sixteen college students were run in three groups and compared under three conditions of display prompting, a stimulus prompt group, a response prompt group, and a stimulus-response prompt group. The hypothesis of greater effectiveness of the stimulus prompt compared with the response prompt groups was confirmed and statistically significant. Differences between the stimulus prompt group, and the stimulus-response prompt group were not significant.

These findings are discussed in relation to instructional requirements and the evaluation of learning in dialog settings.
CHAPTER I

INTRODUCTION

In traditional studies of learning the sequences and rates of information presentation is determined by the experimenter or the system on the basis of assumption about the learner's processing capability. This procedure may distort the analysis of human information processing in the case that invalid or inappropriate assumptions have been made. In such situations the dialog procedures may prove more appropriate by permitting the learner to control the rate and sequence of information presentation in accordance with his own learning strategies.

Several models of dialog are available. (Harrah (1965a), (1963b), and Pask (1971)). Stapleton (1973) provides thorough analysis of dialog experiments for verbal paired-associate learning and provides a model of the learner's acquisition and rehearsal strategies. Stapleton's analysis, however, has been limited to the verbal learning situation in which the learner does not have access to an external memory. In the present research a dialog experiment was conducted to clarify the effects of a read only visual display on verbal learning and retention.

Models of Memory

For present purposes, two models of memory may be contrasted.
Broadbent (1958) and others (Hebb (1949), and Milner (1967)) have proposed the existence of functionally different levels of memories. The main distinction is between short term memory (STM) and long term memory (LTM).

STM is a memory from which information is lost in at most 30 seconds and may be retained in STM by rehearsal. Information selected for more permanent storage enters LTM, primarily via rehearsal. Forgetting from LTM may be due to actual loss of items from memory, or inability to retrieve stored information. The capacity of LTM is unknown. It should be noted that visual and short term memories proposed originally by Sperling (1963) and emphasized by the research of Posner (1969), Keele and Chase (1969), are not considered relevant to the present analysis since the subject's in these experiments, view the display for only a few milliseconds, and information is only briefly available from this store (approximately one second or less).

In contrast to concepts of functionally distinct memories are models of memory which do not distinguish between STM and LTM but which account for research results in terms of levels of processing. For example, Dillion and Reed (1969) have proposed that the deeper the level of processing the more likely the entry into LTM. Both views indicate the need to determine retention over longer time intervals to assess learning.

**Paired-Associate Task**

A number of analyses of the paired-associate tasks have been proposed. (Bower (1961), Bush and Mosteller (1955), Restle (1965),
Kintsch (1963), and Atkinson and Crothers (1964)). One difference of interest in the present research is the postulated number of stages of learning. For example, McGuire's model postulated three stages of paired-associate learning, a stimulus learning stage, a response learning stage, and an association of stimulus and responses. Newman (1961) and Battig (1968) have proposed even more detailed analysis of stages of learning paired-associates. These models made explicit the problem of determining what is learned in paired-associate tasks.

**Stimulus Selection**

Underwood (1963), in a review of studies of paired-associates showed that if the stimulus terms consist of several unrelated components only some of these components become functional as a consequence of paired-associate learning. The subject selects components of a complex stimulus and learns only the association between these selected components (the functional stimulus) and the response.

The stimulus selection experiments in paired-associate learning show that if offered a choice, subjects select among the components of a stimulus and thereby simplify the task for themselves. (Trabasso and Bower (1968)). However, under some conditions subjects respond to all components of a stimulus situation. In these studies at least some of the stimulus items have common components. (Binder and Estes (1966), and Binder and Feldman (1960)). Kintsch has summarized the results by stating subjects start with some simple selection strategy. He noted further if the problem is such that simple
strategies do not work then more complex codes will be tried until a solution is achieved. The limited information-processing capability of subjects restricts them to trying only one or at most a few coding operations simultaneously.

In the present task (see Figure 1) it is assumed that the stimuli in the display may be analyzed into at least two components. One component consists of the digits presented and encoded by its name. Thus, when presented with the printed number "33" it is assumed that the subject encodes the presented stimulus by its name "thirty-three". The second component consists of its serial position in the display. Thus the first digit on the left of the stimulus row is encoded as the first stimulus, the next digit in the row as the second stimulus, et cetera. This is diagrammed in Figure 1. The notion that serial position is a "stimulus" has been proposed by Ebenholtz (1963).

**Stimulus Selection Paradigm**

In stimulus selection studies subjects learn a paired-associate list in which the stimulus items consist of two or more components and a different response is consistently paired with each compound. In the present case, for example, it is assumed that the components consist of the serial position and the stimulus name.

Following learning of the paired-associate list the components are presented individually and subjects are asked to recall the response that had been paired with the compound containing the component. Stimulus selection is inferred from the differential effectiveness of the components from a compound, as cues for recall. The most effective
Figure 1. Analysis of Stimulus Components in Visual Display.
cue is said to be selected. Additional restrictions concerning time sharing factors, and possible association between stimulus components has been discussed by Richardson (1972).

In the present study this paradigm is modified. The visual display presents both stimulus and response elements on serial order by rows. Twenty-four hours later, and after initial recall, the subject received a prompted recall which consists of either the ordered stimuli, the ordered responses, or the original display, in which both stimulus and response elements are presented. The unaided recall requires the subject to recall one component (the name) and its associated response. Since the stimuli (digits) are well known it is assumed that the stimulus names are available to the subject. Coulter (personal communication) has demonstrated that subjects are unable to recall stimulus names in their appropriate serial order under acquisition conditions identical to those in the present experiment.

In the modified paradigm only one stimulus component (stimulus name) is utilized in testing retention in initial unaided recall. This reflects the requirements of instructional settings in which students learn with visual aids, and are later required to retain information without access to the initial visual display. The subsequent prompted recall permits an analysis of the initial learning situation, and the effects of display characteristics on retention.

Theoretical Analysis of Acquisition

As shown in the following Figure 2 it is assumed that (a) associations are formed between the stimulus component (serial position)
Stimulus

name          order

Response (letter)

Association___________

Note: No associations are formed between the stimulus components.

Figure 2. Analysis of Acquisition for a Stimulus-Response Pair.
and the response, (b) associations are also formed with the stimulus component (name) and the response, and (c) no associations are formed between the two stimulus components. This last point has been demonstrated by Coulter as noted earlier. Using a display identical to the display used in the present research he found that subjects were unable to order the stimuli in the order shown in the display presentation after a 2½ hour interval (personal communication).

**Analysis of Unaided Recall**

Subjects are required to present the stimulus component (digit name) and associated response (Figure 3). Note that since it is assumed that stimulus name is not associated with serial position during acquisition, the subject is unable to recall serial position of the stimulus. In the stimulus prompt situation (Figure 4) the two stimulus components are presented simultaneously so that the subject can (a) retrieve the stimulus serial position component and its associated response, and (b) determine the required stimulus component name by its locus in proper serial position in the display. In this case the subject should be able to retrieve additional stimulus-response pairs. In the response prompted condition the subject cannot give required stimulus component (name) since the display only gives serial order of responses without the associated stimulus component name. The stimulus-response display constitutes a control condition, and based on this analysis is identical with the stimulus prompt condition.
Response Test:

Stimulus component (name) $\rightarrow$ Response

Acquisition:

Stimulus component (name) $\rightarrow$ Response

Stimulus component (serial position) $\rightarrow$ Response

Stimulus component (serial position) $\rightarrow$ Response (name)

Strong Association $\rightarrow$

Weak Association $\rightarrow$

No Association $\rightarrow$

Figure 3. Analysis of Unaided Recall.
Figure 4. Analysis of Stimulus Prompt.
This analysis of the stimulus selection paradigm was undertaken to demonstrate its applications to instructional situations utilizing visual displays, e.g., subjects learn from a display in which materials are ordered in appropriate serial position, however, later recall requires that the item name be associated with response items.

**Hypothesis to be Tested**

The hypothesis is as follows. Under dialog conditions subjects will utilize serial order in a visual display as a selected stimulus component in addition to stimulus name. These two stimulus components (serial position of stimulus item, and the name of the stimulus item) are not associated during acquisition. Recall tasks which require subjects to indicate recall be associating stimulus name with response name is a common instructional requirement, and provides an incomplete measure of acquisition. This can be demonstrated by the differential effects of display prompts. An effective display prompt should indicate association of the stimulus name and its serial position in the display. This type of prompt aids retention by enabling the subject to utilize associations formed between the stimulus component serial position, and the response. Displays which indicate the serial order of responses in the acquisition situation will be ineffective in prompting recall.
CHAPTER II

EXPERIMENT

Subjects

Twenty-one undergraduate college students from an introductory psychology class were used in this study. Subjects received one hour class credit for participation in the experiment.

Apparatus

The acquisition displays consisted of stimuli and responses typed on an 8 1/2" x 11" page and then copied by a commercial dry copier. The stimuli consisted of the 12 typed capital letters B-M inclusive and the responses were the numerals 12-23 inclusive. The display consisted of two six-inch long rows set in pica type and separated by 1 1/2 inches. The top row, being the stimulus set, was offset 1/4 inch to the right of the bottom row. This display can be found in Appendix A. This display was held at normal reading distance by the subject. The retention task used displays derived from the acquisition display. Two retention displays were produced by taking the acquisition display and blocking either the stimuli portion of it or the response portion of it while copying it with a commercial dry copier. A third retention display was identical with the acquisition display. These can also be found in Appendix A.
Task

There were two tasks separated by a period of approximately 24 hours. The first task is an acquisition task and the second task is a retention task.

Acquisition Task

The acquisition task consists of learning a one-to-one rule between the elements of the stimulus set and the elements of the response set. The method used was a dialog procedure. The criterion of learning is a rehearsal of all 12 stimulus-response pairs (henceforth called "items") with no errors.

The dialog procedure consisted of the subject asking the experimenter one of three different forms of a yes-no question. The questions are either AND questions, OR questions, simple questions, and negations of AND, OR, and simple questions. For AND and OR types of questions there is no constraint as to the number of items allowed or the order in which they must appear. The AND, or conjunctive, question is of the form "Does 17 go with B, and 22 go with D and 13 go with G?". The experimenter responds yes to each question depending on predetermined stimulus-response pairs. The OR, or disjunctive, question is of the form "Does 17 go with B, or G, or F, or G, or I, or K?". In order for the experimenter to respond yes then the correct response must be one or more of the responses that was named. Disjunctive questions of the form "Does A go with 17 or B go with 22?" are also allowed. Simple questions are of the form "Does 17 go with B?" and specify a single stimulus-response pair. Typically the dia-
junctive question is used for acquiring new rules between the stimulus and response sets and conjunctive questions are used for rehearsing items previously acquired.

The subjects were requested to rehearse aloud to insure all rehearsals were overtly displayed. The acquisition task was the same for all subjects.

Retention Task

Twenty-four hours after completing the acquisition task subjects were given retention tasks. Subjects were randomly assigned to one of three recall tasks. Note that the acquisition task was identical for all subjects. The three conditions of retention were stimulus prompted, response prompted, and stimulus-response prompted. The difference between these three conditions was the differences in the visual displays given to the subjects.

Before the subjects were assigned into these groups they were required to recall all the items they remembered. This initial recall was unaided and no display was provided. After the unaided recall subjects served in one of three prompted recall conditions. The subjects in the stimulus recall group were given a visual display task in which only the stimulus portion of the acquisition display was present. The subjects in the response recall group were given a visual display with only the response portion presented. The subjects in the stimulus-response group received the identical display as in the acquisition task.
In a third recall condition the subjects in the stimulus recall group and the response recall group were given an additional recall task. This task was the same task the stimulus-response group received, and recall was prompted by the acquisition display.

Procedure

The subjects were seated across from the experimenter. The experimenter then proceeded to read the instructions to the subjects. The instructions consisted of two parts; the first part contained the material to be read to the subjects and the second part consisted of simple tasks for the subjects to respond to in order to show their understanding of the given instructions.

After the initial instructions were completed a practice task was started. This task is similar to the experimental task. The stimuli and responses were the numbers 300-305 and 400-405, respectively, instead of the letters B-M inclusive and the numerals 12-23 inclusive. The instructions read to the subjects can be found in Appendix B.

The entire learning procedure for the experimental task was tape recorded. For the first six subjects instructions were also recorded so that an independent observer could verify the consistency of the experiment. When the acquisition task was completed the subjects were told by the experimenter that a different experimenter would conduct an experiment the second day of the experiment. This was undertaken to avoid rehearsal during the intervening 24 hours.
For the second day the subjects were again seated in the same place as the first day. Since the instructions were short they were included in the recording of the experiment. The subjects were first told to tell the experimenter all the items they could recall unaided. When the subjects indicated they had completed the unaided recall task the experimenter administered the appropriate prompted recall task. The second prompted recall task was administered to the subjects who had previously served in the stimulus or response prompted recall conditions.

**Recording of Data**

All material contained on the tapes were transcribed. Questions and their answers were divided into two categories. One category being acquisition questions during which the subjects typically searched the response set for the correct element and rehearsal questions which consisted of all questions asked subsequent to the discovering of a correct stimulus-response association. All subjects divided the task into a set of subtasks which consisted of each item and its associated response. While it is possible for subjects to on occasion infer stimulus-response associations by exhaustion of the response set during acquisition only initial overt questions associating a particular stimulus and response were counted as acquisitions.

**Rehearsal Data**

There were five measures of rehearsal taken. All rehearsal questions were divided into two groups, rehearsal questions which were
correct (i.e., it received a yes answer from the experimenter) and rehearsal questions which were incorrect.

If a rehearsal question was correct then a count was taken for each item in the rehearsal. If the question was incorrect then it was further checked to see if there was more than one item involved in that rehearsal question. If there was only one item involved then the error would be recorded by the stimulus present. This is the second measure. If there were multiple items in the rehearsal question then third and fourth measures would be taken. The third measure represents the correct items in an incorrect rehearsal question and the fourth measure is the count of the incorrect items (again counted by the stimulus portion). The fifth measure is the count of redundant acquisitions. Once an item is acquired and later used in a disjunctive question then all disjunctive questions containing that item are defined to be "redundant acquisitions". This category of disjunctive questions was defined since such questions are ambiguous psychologically. They may be considered as acquisition or rehearsal questions depending on interpretation which varies with subject's previous behavior. Appendix C contains the complete algorithm for computing these measures.

Three measures of recall were recorded. The first (unaided recall) and second (prompted recall) tasks are presented in the analysis. Preliminary analysis indicated the third prompted measure did not provide discriminatory data and therefore was not further analyzed. The scoring of the two initial recall tasks were identical.
The data was transcribed in the same order as it was elicited from the subjects thereby making the last item the most recent one. It has been assumed that the last item given by the subjects is the one they want to use. Therefore, to delete the duplicate items the last one is used as a template. If any previous items have the same stimulus or response elements as the template item that item is deleted. When this is done for all items it is repeated again using the next non-deleted item in the recall list. When there were no more items to use as a template the data was ready for scoring.

The first measure was for each correctly recalled item that was not deleted. The second and third measure was for each incorrectly recalled item that was not deleted. The second measure counts the incorrect items grouped by the stimulus portion of the item in question and the third measure counts the incorrect items by the response portion of the item in question. Appendix D contains the complete algorithm for computing these measures.

Error Data

A measure was taken to indicate the location of rehearsal errors in multiple pair rehearsal questions. For each rehearsal the first item elicited from the subject is considered to be in serial position one, the second item in serial position two, and so on. Since there are 12 items to learn 12 counts were maintained with one representing each serial position. Whenever a rehearsal item was incorrect a count was added to the appropriate serial position count.
CHAPTER III

RESULTS

Discussion of Acquisition

All subjects, with two exceptions, learned the correct items using the same strategy. They divided the task into 12 subtasks with each subtask consisting of finding a response associated with a particular stimulus. The subjects took the leftmost stimulus element from the stimulus set and used it as the first subtask. When this was completed they used the next stimulus element in the stimulus set (i.e., they went in the same order as the stimuli were presented in the display). After each acquisition of a stimulus-response pair the subjects rehearsed all previously acquired items up to and including the one just acquired (again in the same order in which they were presented).

The remaining two subjects differed in the method they used for selecting the stimulus for each subtask. One subject divided the responses in half and first found all the stimuli connected with the leftmost half of responses. Then the remaining responses were connected to the correct stimuli. This subject had an acquisition time of 285 units, which is slightly below average and a perfect recall after 24 hours. The other subject selected the stimuli in numeric order. His acquisition time was 510 units, which is the longest, and his initial recall of six items is substantially above
average.

Strategies

Subjects displayed acquisition strategies which can be considered under one of three headings, namely, single item strategy, partition strategy, and the binary search strategy. These strategies are related to methods used to select response elements usually via disjunctive questions. The single item strategy is one in which each question contained only one response element. The partition strategy, for a disjunctive question, is where more than one response element is included in a question. There is no limit on the number or order of elements that can be asked about. The binary search is a special case of the partition strategy. With this method the partition width (number of response elements in the disjunctive question) is governed by the number of unassociated response elements in the response set. This search is an iterative process with a partition width of one-half the unassociated items. For example assume there were eight response elements. The subject would use a partition width of four and ask about the first four elements. If the answer is yes he might then use a partition width of two and ask about the first two elements. If the initial answer was no the subject might use a partition width of two for the first two response elements of the four unused ones (i.e., not the ones in the first question). This method would be repeated until the correct response element is discovered.

No subject showed a consistent binary search throughout the
entire task although some subjects, during portions of the task, asked disjunctive questions consistent with the binary search strategy. This was unanticipated since subjects were instructed in the binary search strategy. In this instruction they were also required to solve two problems using this strategy to demonstrate their understanding of this method for searching through the response set. This result raises some question as to the effectiveness of the instruction in inducing a binary search strategy.

The instructions also stated that once a response had been connected with a stimuli then it was an error to use this response in further disjunctive questions. Analysis of disjunctive questions for each subject indicates that 13 of the 16 subjects deleted previously paired responses from their disjunctive questions. Three subjects failed to delete such responses. There are no apparent differences in acquisition times, recall scores, and the number of questions asked for subjects who did and did not delete. This suggests that deletion, or failure of deletion, should be interpreted cautiously in interpreting subject behavior. A left-to-right bias for acquisition is prevalent among 15 of the 16 subjects as shown by Table 1. This may reflect transference from reading habits.

Discussion of Rehearsal

As reflected Table 2 shows the percentage of errors in rehearsal by order of acquisition. Note that the amount of rehearsal is a function of serial position. Since, as already noted, order of
acquisition was from left-to-right in the initial display. Table 2 indicates the left-to-right order of the stimulus-response pairs presented in the initial display. Except for the initial and end items there is little evidence for serial position effects.

An analysis was made of rehearsal errors within multi-item conjunctive questions, e.g., "Does 17 go with B and 22 go with G and 13 go with D?". It was noted that pairs in conjunctive questions were asked in order of acquisition thus the first pair in conjunctive questions tended to be the first pair learned with the second pair in the conjunctive question being the second pair learned and so on. On the basis of this analysis it appears that the initial items in the conjunctive questions would therefore have been rehearsed more frequently in the case of multiple rehearsals. This leads to the prediction that the last item in the conjunctive question is more likely to be in error. This is reflected by Table 3 where the x-axis shows the number of items in the conjunctive question and the y-axis shows locus for error of incorrect stimulus-response pairs. For conjunctive questions up to eight items the table clearly shows the anticipated pattern of error, with the last item in the question showing a higher error rate. Questions with more than eight items tended to show errors distributed as anticipated in which the last several items show higher errors. There is also some tendency for errors to occur at the beginning of the question for question lengths of 9 and 12 items. One interpretation of this result is that differential retention effects occur in conjunctive questions of item lengths 2-6 and conjunctive question of item lengths 9-12. This differential
effect may be due to the number of items that may be held in short
term memory (STM). Available data indicates that the number of items
held in STM to be $7 \pm 2$ (Miller, 1956).

Conrad (1959, 1965) has noted that transpositions of order,
for example recalling "VNSBPX" when the actual series is "WNSPBX",
are the most common errors in immediate memory (i.e., STM). He
indicates that in immediate memory for letters transpositions do
not occur at random. Instead it is primarily letters which sound
alike that are transposed. This suggests that a transposition may
be a double substitution that happened to look like an inversion of
order. He notes also that the stimulus list contains no doubled
letters therefore a subject who has made a substitution of "F" for "P"
as in the example will not go on to say another "B" and recall "VNSBBX"
but will probably make a second substitution; therefore "P" will
replace "B". The results of these two successive substitutions is an
apparent inversion.

The types or errors made in the present experiment were of the
sort noted by Conrad, and were therefore, typical of the error in
immediate memory.

Even though the acquisition and rehearsal strategies employed
by the subjects were similar, Table 4 shows there was substantial
individual differences between subjects in learning to criterion.
On acquisition time the slowest subject took nearly nine times longer
as the fastest subject, and yet the difference in the number of
questions asked was only on the order of five to one. This indicates
long acquisition time is not necessarily characterized by how many questions are asked but may reflect different processing rates. Initial recall average of 2.83 items verifies the finding of Coulter (personal communication) who obtained an initial recall of 2.16 items.

**Analysis of Rehearsal and Retention**

Total and between subjects correlations were calculated between all 11 measures (the five rehearsal measures as described in the section on Rehearsal Data and the six recall measures as described in the section on Recall Data). On the basis of these correlations the following variables were chosen for further analysis: correctly rehearsed items (A), single items rehearsed incorrectly (B), correct items within an incorrect rehearsal (C), incorrect items within an incorrect rehearsal (D), correct initial recall (F), and incorrect stimuli in initial recall (G). It was predicted that number of correct rehearsals would predict correct items recalled and that errors in rehearsal would be related to errors in recall.

The results of the within group of correlation for these variables in Table 5 indicate that correctly rehearsed items and correctly rehearsed items within incorrect rehearsals are correlated of .697, as anticipated. By the same token, incorrect rehearsals in single item and multiple item rehearsals both agree with a correlation of .524. In terms of initial recall both correct rehearsal measures (variables A and C) are positively correlated with initial recall and the two measures of rehearsal errors (variables B and D) show no correlation with initial recall errors. The correlations of the two measures of correct items
(variables A and C) with initial recall are significant being 2.1 and 2.3 standard deviations above zero. The degrees of freedom for these correlations is 175.

**Discussion of Recall**

The order of the recalled items reflect the order of acquisition and the amount of rehearsal. Sixty-five percent of the correctly recalled items were the first six items of the list. In addition, as anticipated, there was substantial overlap between items initially recalled during unaided response and items recalled during prompted response. Table 6 shows the chi-squares for the Stimulus, Response, and Stimulus-Response groups. This shows that the overlap of recalled items for unaided and prompted recall is significant for all three prompted groups.

Analysis of variance was performed on recall scores derived from subtracting initial recall from prompted recall. Appendix E contains the raw data for all subjects. Table 7 presents a statistical analysis of the differential effects of stimulus, response, and stimulus-response prompts.

The analysis of variance for comparison of all three groups is significant at the .01 level. This permits pairs of conditions to be compared statistically. In these comparisons both the Stimulus, and the Stimulus-Response group were significantly superior to the Response group at the .01 and .001 level respectively. Differences between the Stimulus and the Stimulus-Response group did not reach significance. The pooled error estimate was used for all individual pair tests.
One subject's protocol provides additional confirmation of the hypothesis that the stimulus component serial position was associated with the response. In this subject's unaided recall he was unable to give a single correct stimulus (name)-response association. His tape recording reveals however that he was able to give stimulus (serial position)-response associations. During the response prompted conditions the subject gave one correct stimulus (name)-response association. However, he was able to verbalize stimulus (serial position)-response associations and did so spontaneously. His protocol is given in Appendix F and indicates that he was able to recall eight such associations correctly.
Table 1. Order of Acquisition in Percentages

<table>
<thead>
<tr>
<th>Items</th>
<th>17B</th>
<th>22G</th>
<th>13D</th>
<th>16K</th>
<th>20I</th>
<th>23F</th>
<th>14M</th>
<th>19K</th>
<th>12J</th>
<th>18E</th>
<th>21L</th>
<th>15C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>64</td>
<td>100</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Serial Position of Acquired Pairs
Table 2. Analysis of Rehearsal Errors by Serial Position

<table>
<thead>
<tr>
<th>Serial Position</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Errors</td>
<td>0</td>
<td>7</td>
<td>28</td>
<td>20</td>
<td>16</td>
<td>16</td>
<td>21</td>
<td>10</td>
<td>13</td>
<td>9</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Number Correct</td>
<td>218</td>
<td>215</td>
<td>219</td>
<td>197</td>
<td>168</td>
<td>156</td>
<td>144</td>
<td>121</td>
<td>110</td>
<td>92</td>
<td>60</td>
<td>53</td>
</tr>
<tr>
<td>Total Number of</td>
<td>218</td>
<td>223</td>
<td>247</td>
<td>217</td>
<td>164</td>
<td>172</td>
<td>165</td>
<td>131</td>
<td>123</td>
<td>101</td>
<td>61</td>
<td>75</td>
</tr>
<tr>
<td>Rehearsals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Errors</td>
<td>0</td>
<td>3</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>13</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>2</td>
<td>29</td>
</tr>
</tbody>
</table>
Table 3. Number of Errors by Serial Position in Rehearsal Questions

<table>
<thead>
<tr>
<th>Serial Position</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errors</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>18</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Number of Items</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Number of Items in Rehearsal Question
Table 4. Initial Data

<table>
<thead>
<tr>
<th>Category</th>
<th>Average Score</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition Time</td>
<td>303 units</td>
<td>88-510 units</td>
</tr>
<tr>
<td>Initial Recall</td>
<td>2.83 items</td>
<td>0-6 items</td>
</tr>
<tr>
<td>Second Recall with Stimulus Display</td>
<td>5.67 items</td>
<td>3-9 items</td>
</tr>
<tr>
<td>Second Recall with Response Display</td>
<td>1.86 items</td>
<td>0-3 items</td>
</tr>
<tr>
<td>Second Recall with Stimulus-Response Display</td>
<td>7.60 items</td>
<td>5-10 items</td>
</tr>
<tr>
<td>Number Questions Asked (total)</td>
<td>119 questions</td>
<td>48-256 questions</td>
</tr>
</tbody>
</table>
Table 5. Correlation of Within Subjects

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(</td>
<td>.077</td>
<td>.697</td>
<td>.140</td>
<td>.155</td>
<td>.069</td>
</tr>
<tr>
<td>B</td>
<td>.077</td>
<td>(</td>
<td>.141</td>
<td>.524</td>
<td>.014</td>
<td>.065</td>
</tr>
<tr>
<td>C</td>
<td>.697</td>
<td>.141</td>
<td>(</td>
<td>.170</td>
<td>.171</td>
<td>.017</td>
</tr>
<tr>
<td>D</td>
<td>.140</td>
<td>.524</td>
<td>.170</td>
<td>(</td>
<td>.067</td>
<td>.095</td>
</tr>
<tr>
<td>F</td>
<td>.155</td>
<td>.014</td>
<td>.171</td>
<td>.067</td>
<td>(</td>
<td>.307</td>
</tr>
<tr>
<td>G</td>
<td>.069</td>
<td>.065</td>
<td>.017</td>
<td>.095</td>
<td>.307</td>
<td>(</td>
</tr>
</tbody>
</table>
Table 6. Chi-Squares for Items Correctly Recalled on Initial Trial and Prompted Trial

<table>
<thead>
<tr>
<th>Group</th>
<th>Chi-Square</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulus Group</td>
<td>8.57</td>
<td>.01 level of significance</td>
</tr>
<tr>
<td>Response Group</td>
<td>11.17</td>
<td>.001 level of significance</td>
</tr>
<tr>
<td>Stimulus-Response Group</td>
<td>10.24</td>
<td>.01 level of significance</td>
</tr>
</tbody>
</table>

.01 level of significance 6.54
.001 level of significance 10.83
### Table 7. Analysis of Variance

**Comparison of Stimulus, Response, and Stimulus-Response Prompt**

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>df</th>
<th>Variance</th>
<th>$F$</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2_T$</td>
<td>59.75</td>
<td>15</td>
<td>3.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^2_{BG}$</td>
<td>34.42</td>
<td>2</td>
<td>17.21</td>
<td>6.83**</td>
<td>2/13</td>
</tr>
<tr>
<td>$\chi^2_{WG}$</td>
<td>25.33</td>
<td>13</td>
<td>1.95</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comparison of Stimulus and Response Prompt**

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>df</th>
<th>Variance</th>
<th>$F$</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2_{BG}$</td>
<td>17.51</td>
<td>1</td>
<td>17.51</td>
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<td></td>
</tr>
</tbody>
</table>

Error: 1.95 8.96* 1/13

**Comparison of Stimulus and Stimulus-Response Prompt**

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>df</th>
<th>Variance</th>
<th>$F$</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2_{BG}$</td>
<td>3.11</td>
<td>1</td>
<td>3.11</td>
<td>1.59***</td>
<td>1/13</td>
</tr>
</tbody>
</table>

**Comparison of Response and Stimulus-Response Prompt**

<table>
<thead>
<tr>
<th></th>
<th>$\chi^2$</th>
<th>df</th>
<th>Variance</th>
<th>$F$</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2_{BG}$</td>
<td>32.4</td>
<td>1</td>
<td>32.4</td>
<td>16.62**</td>
<td>1/13</td>
</tr>
</tbody>
</table>

* Significant at .05 level.
** Significant at .01 level.
*** Not significant.

F test for df 2/13 1/13

<table>
<thead>
<tr>
<th>.05</th>
<th>.01</th>
<th>.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.83</td>
<td>6.66</td>
<td>12.83</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>.05</th>
<th>.01</th>
<th>.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.67</td>
<td>9.07</td>
<td>17.81</td>
</tr>
</tbody>
</table>
Table 8. Rehearsal Data Collection Form

<table>
<thead>
<tr>
<th>PAIRS</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>17B</td>
<td>Entire rehearsal correct.</td>
<td>One pair incorrect.</td>
<td>Multiple pair rehearsal incorrect, individual pair correct.</td>
<td>Multiple pair rehearsal incorrect, individual pair incorrect.</td>
<td>Redundant rehearsal.</td>
</tr>
<tr>
<td>22G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12J</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9. Recall Data Collection Form

<table>
<thead>
<tr>
<th>Initial Recall</th>
<th>Second Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

PAIRS

17B
22G
13D
16A
20I
23F
14M
19K
12J
16E
21L
15C

A  Correct stimulus and response
B  Correct stimulus with incorrect response
C  Correct response with incorrect stimulus
CHAPTER IV

CONCLUSION

The hypothesis that stimulus selection based on locus of information may be an important factor in the utilization of visual displays was confirmed (see Table 7).

In instructional settings the analysis provides an explication of what is learned, which promises to have wide applications. Instructional requirements tend to emphasize the importance of the name encoding. The encoded serial position in the display is usually arbitrary and not reflected in the evaluation of displays in instruction. The research supports an analysis which indicates that users learn to associate both components of the stimulus information displayed with required responses. However, the two stimulus encodings do not appear to be associated with each other in the paired-associate tasks analyzed. Retention which reflects only the instructional requirement – namely the stimulus name encoding – does not demonstrate the additional association based on serial position encoding. Therefore, assessment of learning with visual displays is incomplete unless the serial position encoding and its associated response are also tested.

Finally, the research suggests that an effective visual prompt is one which associates both name and serial position encodings in
the display. Such a display permits the subject to utilize the serial position encoding in eliciting the correct response. Note however that such prompts are usually incompatible with instructional requirements since they assume that the learner can assess the display during retention. In most instructional settings it is assumed that the learner can retain information without access to a prompt display. This is particularly the case in which the serial order of eliciting stimuli is arbitrary. In general, it is suggested that subjects may have acquired a number of stimulus encodings which depend on display format and that these encodings should be considered in evaluating display effect in learning. Serial position in the display appears to be one important format consideration, although others may be hypothesized for further research.

**Suggested Research Areas**

Additional research is required to clarify the following:

(a) Determination of display characteristics which are related to subjects encoding of locus as a stimulus component. Other aspects of locus in addition to serial position require analysis and investigation.

(b) Since both stimulus components (name and serial position) elicit responses which are well learned the present study does not provide an analysis of the factors responsible for selection of a particular component. The utilization of a dialog method may also be a factor since subjects are free to acquire information in a left-
to-right order. Other methods of presentation and display format may well reduce the strength of associations to the order component, and should be considered.

(c) Further research is required to provide detailed information on the subject's interaction with the display in initial acquisition. If the subject's reading responses are an important factor this might be revealed by analysis of eye movements, et cetera. Manipulation of displays by computer driven cathode ray tube (CRT) displays may also provide a method for a refined analysis of subject's visual processing.
APPENDIX A

DISPLAYS

Initial Display and Stimulus-Response Prompt

17 25 13 16 20 23 14 19 12 18 21 15

F J B I D K C M H L G E
Correct Stimulus-Response Pairs

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 B</td>
<td>12 J</td>
</tr>
<tr>
<td>13 D</td>
<td>13 D</td>
</tr>
<tr>
<td>22 G</td>
<td>14 M</td>
</tr>
<tr>
<td>16 H</td>
<td>15 C</td>
</tr>
<tr>
<td>20 I</td>
<td>16 H</td>
</tr>
<tr>
<td>23 F</td>
<td>17 B</td>
</tr>
<tr>
<td>14 M</td>
<td>18 E</td>
</tr>
<tr>
<td>19 K</td>
<td>19 K</td>
</tr>
<tr>
<td>12 J</td>
<td>20 I</td>
</tr>
<tr>
<td>18 E</td>
<td>21 L</td>
</tr>
<tr>
<td>21 L</td>
<td>22 G</td>
</tr>
<tr>
<td>15 C</td>
<td>23 F</td>
</tr>
</tbody>
</table>
Stimulus Prompt

17 22 13 16 20 23 14 19 12 18 21 15

- - - - - - - - - - -
Response Prompt

- - - - - - - - - - - -

F J B I D K C M H L G E
INSTRUCTIONS TO THE SUBJECT

The following instruction will be read to all subjects on the first day of their participation:

"We are interested in human information processing models of learning. The goal of this experiment is to discover how efficiently individuals can learn materials without error. The experiment you are participating in is a simple learning task.

You will be given a list of two-digit numbers and a list of single letters. One-to-one associations among the letters and numbers have been previously assigned. That is, each number is associated with one letter and vice versa. There are an equal number of items in each list. Your task is to learn which number goes with which letter. You will have completed the task when you can give all pairs of letters and numbers without interruption.

For example, suppose the numbers are 34, 35, 36, and 37, and the letters are W, X, Y, and Z. Assume that W goes with 37, X goes with 35, Y goes with 36 and Z goes with 34. [show subject a paper exhibiting these pairs (Figure 5)]* At the beginning of the experiment

*Statements in brackets [ ] are not read to the subject. They are to remind the experimenter of certain actions and/or for explanatory purposes.
W - 37
X - 35
Y - 36
Z - 34

Figure 5. Subject Handout.
only the experimenter knows which number goes with which letter. You must discover the correct pairs by asking the experimenter questions. There are three kinds of questions you can ask: AND questions, OR questions, and negations of such questions. Of course you may also ask simple questions such as "Does X go with 34?". In our example, the experimenter would answer "NO" because X goes with 35.

A subject might ask a more complicated question such as the OR question "Does X go with 34 or 35?". In this case the answer is YES since X goes with 35. A question such as "Does X go with 35 and Y go with 34?" is an AND question. The answer is NO because Y goes with 36.

To be sure you understand how to interpret these various types of questions, please let me ask you some questions based on the example before you. Please respond YES or NO to my question.

Does Y go with 35, 36, or 37? [YES]
Does Y go with 36 or does X go with 37? [YES]
Does W go with 37 and X go with 34? [NO, X = 35]
Does X go with 35 and Y go with 36? [YES]

It is very important that you try to learn these pairs without making any errors. Once you have learned a correct pair, you should not forget it before you learn all of the other pairs. This will undoubtedly mean that you must rehearse previously acquired information; that is, you may repeatedly ask about previously acquired information to insure that you have not forgotten those pairs. Consider the example concerning the numbers 34, 35, 36, and 37, and the letters W, X, Y, and Z. Suppose the subject has learned that W goes with 37 and
that X goes with 35. Before finding the matches for Y and Z, the subject may choose to ask the rehearsal question "Does W go with 37 and X go with 35?" in order to be sure he has not forgotten those pairs. A rehearsal question is usually an AND question.

Rehearse anytime you feel you must. It is not necessary to try to minimize rehearsals - rehearse as often as you want to. You may rehearse as many of the previously learned pairs as you want to. Also, I would like for you to vocalize all rehearsals so that I can inform you whether or not your rehearsal is correct.

It is also an error to ask about a previously learned item while searching for some other item. For example, suppose you had already learned that X goes with 35. Then you should not ask "Does 36 go with X or Y?" because the match for X has already been determined.

Do you have any questions?

To be sure I have properly explained the task to you, I would like for you to learn a small number of pairs by the procedure described to you. [During the trial session, an attempt is made to determine if the subject understands the task by observing his performance. Also, this allows the subject to clarify any misunderstanding.]

[Past experimentation has indicated that it is not always clear to the experimenter when a subject has completed a rehearsal. This is because a subject may rehearse all or only portions of previously acquired information. Therefore, during the trial run, the subject will be requested to indicate the end of a rehearsal question and to continue those signals in the following experiment.]
Since you will learn the larger number of pairs with the aid of a visual display, you may use this display for this task [hand subject a display sheet (Figure 6).] Your task is to match the numbers on the top line with the ones on the bottom line. Remember, each number on the top line matches exactly one number on the bottom line and vice versa. You may look at the display at any time but you may not write on it or make any other written notations.

[The trial task is now complete.]

I might also inform you that some procedures for identifying a particular item in a group of items require fewer questions than others. In fact, it can be shown that on the average the fastest way to find the item is to ask questions that eliminate one-half (or as close as possible to one-half) of the remaining items. This procedure is often called the "twenty-question strategy".

For example, consider the row of 16 X's.

\[
\begin{array}{cccccccccccccccc}
X & X & X & X & X & X & X & X & X & X & X & X & X & X & X & X \\
\end{array}
\]

Suppose you were to find some X known to me but not to you. Then, following the method described above, you could ask, "Is the X in the first 8 X's?". Of course, that question is equivalent to the OR question "Is it \(X_1\), or \(X_2\), or \(X_3\), or \(X_4\), or \(X_5\), or \(X_6\), or \(X_7\), or \(X_8\)?". If I said no, you may ask, "Is it in the last 8 X's?" and so on. In this case, four questions will identify the proper X. Look at the figure [give the subject a sheet of paper on which Figure 7 is represented.]
Figure 6. Trial Task.
Figure 7. Subject Handout

by 300's
300 - 401
301 - 405
302 - 403
303 - 400
304 - 404
305 - 402

by 400's
400 - 303
401 - 300
402 - 305
403 - 302
404 - 304
405 - 301

Figure 8. Correct Associations for Trial Task
I have a particular square in mind. Ask me questions to identify it.

I have a number between 10 and 20 in mind. Ask me questions to find it.

Now these are the lists of numbers and letters you are to associate [hand display (Appendix A) to subject]. Each number on the top line is paired with exactly one letter on the bottom line and vice versa.

I might add that the number-letter pairs were assigned randomly so you should not try to discover a predictable rule relating the pairs.

You may now proceed with the task."
APPENDIX C

SCORING PROCEDURE FOR REHEARSAL QUESTIONS

The results of all rehearsals will be tabulated to facilitate the analysis of the data. Each rehearsal was considered to be either correct or incorrect. If each individual pair is correct then the rehearsal is incorrect. A "rehearsal" is defined as the second, or subsequent to the second, occurrence of a stimulus-response pair in a conjunctive question.

The following algorithm will be used for the counting of all stimulus-response pairs in rehearsal questions. The data collection form, as shown by Table 8, is organized for recording data concerning stimulus-response pairs. Occasionally the stimulus-response pair will consist of only half the pair (i.e., the stimulus or response component will be missing). In this case the given portion will be used to determine the appropriate stimulus-response pair. The missing portion is to be considered present and correct. All rehearsal items will be subjected to the following algorithm:

1. If the rehearsal question is correct then each individual pair will be counted in column A.

2. If one pair is present and it is correct then a count will be taken using only the stimulus portion of the pair in column B.

3. If there are multiple pairs and the rehearsal question
is incorrect then each pair will be counted either in column C or D. If the particular pair is correct it will be counted in column C using only the stimulus portion. If the particular pair is incorrect then it will be counted in column D using only the response portion.

(h) All disjunctive questions for learned pairs (i.e., the pairs which appeared in a rehearsal question) will be counted as "redundant acquisition" in column E.
APPENDIX D

SCORING PROCEDURE FOR RECALL TASKS

The results of all recalls will be tabulated to facilitate the analysis of the data. The subject's final response is considered to be the critical response.

The data collection form, as shown by Table 9, was organized for recording data concerning recall pairs. Occasionally the recall pair may consist of only half the pair (i.e., the stimulus or response component will be missing). In this case the given portion will be used to determine the appropriate recall pair. The missing portion will be considered to be present and correct.

The following manipulations must be performed before the data can be counted. All duplicate responses must be marked as "deleted". This is accomplished by starting with the most recent recall pair (i.e., the last one presented by the subject) and comparing it to all preceding recall pairs. If any of the preceding recall pairs has either its stimulus or response portion the same as the most recent recall pair then the preceding recall pair is marked as deleted. When this is finished the next recall pair not deleted becomes the most recent recall pair. This procedure is performed until all recall pairs are either deleted or used as most recent recall pairs.

All non-deleted recall pairs will be subjected to the following algorithm:
(1) If the pair is correct it will be counted in column A.

(2) If the pair is incorrect it will be counted twice. There will be a count for the stimulus portion of the pair in column B and a count for the response portion of the pair in column C.
APPENDIX E

RAW DATA FOR COMPARISONS OF RECALL GROUPS IN TABLE 7

<table>
<thead>
<tr>
<th>Initial Recall</th>
<th>Second Recall</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Recall</td>
<td>Second Recall</td>
<td>Difference</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
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<tr>
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<td>4</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

The "Difference" columns were used for the analysis of variance for computing Table 7.
APPENDIX F

A SUBJECT'S PROMPTED RECALL TASK

Subject was shown the response display as a visual aid for this recall task. His recall was as follows:

17 goes with D.  
Second number goes with G.  
First number goes with B.  
17 goes with B.  
Second number goes with G.  
Third number goes with D.  
Fourth number goes with H.  
Fifth number goes with J.  
Fourth number goes with H.  
Fifth number goes with J.  
Sixth number goes with F.  
Seventh number goes with M.  
Eighth number goes with K.  
Ninth number goes with J.  
Ninth number goes with E.  
Tenth number goes with L.  
Eleventh number goes with C.  
Tenth number goes with E.  
Eleventh number goes with L.  

(deleted) (deleted) (deleted) (correct) (incorrect) (incorrect) (deleted) (deleted) (correct) (correct) (correct) (correct) (correct) (correct) (correct) 9 deleted 2 incorrect
Twelfth number goes with C. (correct) 9 correct

The information in the parenthesis is a product of the scoring algorithm as described in Appendix D. When scoring a recall item as correct the requirement that a stimulus portion and a response portion must be present is being waived. For the purpose of demonstrating this subject's recall procedure a serial position number will be allowed in place of the stimulus itself.
BIBLIOGRAPHY


