

A COMPARISON OF THE EFFECTS OF
PRE-STIMULUS INSTRUCTIONS AND
POST-STIMULUS INSTRUCTIONS FOR
RECOGNITION AND RECALL UPON THE
IMMEDIATE AND LONG-TERM RETENTION
OF UNFAMILIAR VISUAL INFORMATION

Thesis for the Degree of Ph. D.
MICHIGAN STATE UNIVERSITY
THOMAS EDWARD EVANS
1972



This is to certify that the
thesis entitled

The Effects of Pre- and Post-stimulus
Instructions on Recognition and Recall
of
Unfamiliar Visual Information
presented by

Thomas E. Evans

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Psychology

M. Ray Denny
Major professor

Date *Feb. 24, 1972*



~~MAY - 1 1975~~ ~~21~~

~~MAY 16 1975~~ ~~RG6~~

~~MAY 20 1975~~ ~~33~~
~~254~~





ABSTRACT

A COMPARISON OF THE EFFECTS OF PRE-STIMULUS INSTRUCTIONS AND POST-STIMULUS INSTRUCTIONS FOR RECOGNITION AND RECALL UPON THE IMMEDIATE AND LONG-TERM RETENTION OF UNFAMILIAR VISUAL INFORMATION

By

Thomas Edward Evans

Postman, Jenkins and Postman (1948) and Davis, Sutherland, and Judd (1955) have concluded that recognition and recall measures of retention do not reflect different processes. Kintsch (1970) in a review of recent research (Estes & DaPolito, 1967) has suggested, to the contrary, that recognition and recall measures reflect different memory processes. In the present dissertation the conclusions of the earlier studies were questioned, and an alternative set of propositions which support and elaborate upon the Estes and DaPolito hypothesis of independence was offered. Decoding response strength was assumed to be independent of encoding response strength. These processes (encoding and decoding) were assumed to be influenced by the acquisition conditions relevant to each process. It was further assumed that recognition and recall measures of retention differentially reflect these acquisition

conditions. Hence a procedure in which the demands of the task require decoding responses as well as encoding responses will not produce differences between recall and recognition measures of retention. In contrast, an acquisition procedure in which the demands of the task require only encoding responses will clearly produce a deficiency in performance on a recall test, but not on a recognition test, since a recall test is a measure of both encoding and decoding responses. This proposition rejects a strength model of memory for a multi-process model, and suggests that recall-recognition differences will disappear if the demand condition during learning is sufficient.

The present procedure was designed to examine the relationship between temporal placement of instructions, the demands of the tasks set up by the instructions (recognition or recall), and the number of repeated exposures per item. The instructions to recall or recognize were presented either before presentation of items (Pre-Stimulus) or 5 seconds after presentation (Post-Stimulus) for different groups. Each pattern was presented four times, in random order, for .50 seconds. It was reasoned that the Post-stimulus Instructions would not be able to affect the encoding or selective processes, and would affect only the decoding, or central retrieval processes, while the Pre-stimulus Instructions could affect both encoding and retrieval. The results supported unequivocally the

hypothesized importance of central retrieval during learning, with recognition and recall differences disappearing under the recall demand condition.

Turvey (1966) concluded from his analysis of Peterson's (1959) and Sperling's (1960a) data that encoding was the critical process affecting repetition enhancement (i.e., improvement across trials) in experiments on immediate memory. In the present study repetition enhancement effects were found which suggested that a Pre-stimulus demand to recall increases encoding prior to retrieval of peripheral information, which results in improvement across trials. These results were interpreted as indicating that the interaction of central and peripheral information, which is maximized under a pre-stimulus instruction to recall, is the essential condition for perceptual chunking, and hence repetition enhancement, to occur. The Post-stimulus condition produced better performance initially, probably due to the direct retrieval from the visual system; but recall performance did not improve across trials under this condition.

The materials in the study were randomly generated patterns of black squares. Although individual patterns were randomly assigned to pattern sets, pattern set effects were nonetheless significant, with Set 1 recalled and recognized more than Set 2. Differences in consistency of encoding and decoding were postulated to account for the

Pattern Set effects. Changes in encoding errors were analyzed across trials, and the less accurate encoding schemes were found to persevere, with the effects magnified on the 24-hour test. This supported some processing effects described by Haber (1964b).

Models of information flow, and assumptions regarding the interactions of the factors in a multi-process model of memory were discussed. It was concluded that educational practices which are based on the assumption that the use of recognition tests will not change the learning process need to be re-evaluated. The present results suggest, to the contrary, that if a recall demand is not present during original learning, performance on a recall test will suffer. The extension of the Estes and DaPolito findings with verbal materials, to unfamiliar non-verbal materials, indicates that the independence of recognition and retrieval processes is not restricted to the special case of retention of verbal materials.



A COMPARISON OF THE EFFECTS OF PRE-STIMULUS
INSTRUCTIONS AND POST-STIMULUS INSTRUCTIONS
FOR RECOGNITION AND RECALL UPON THE
IMMEDIATE AND LONG-TERM RETENTION
OF UNFAMILIAR VISUAL INFORMATION

By

Thomas Edward Evans

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

1972

674554

TABLE OF CONTENTS

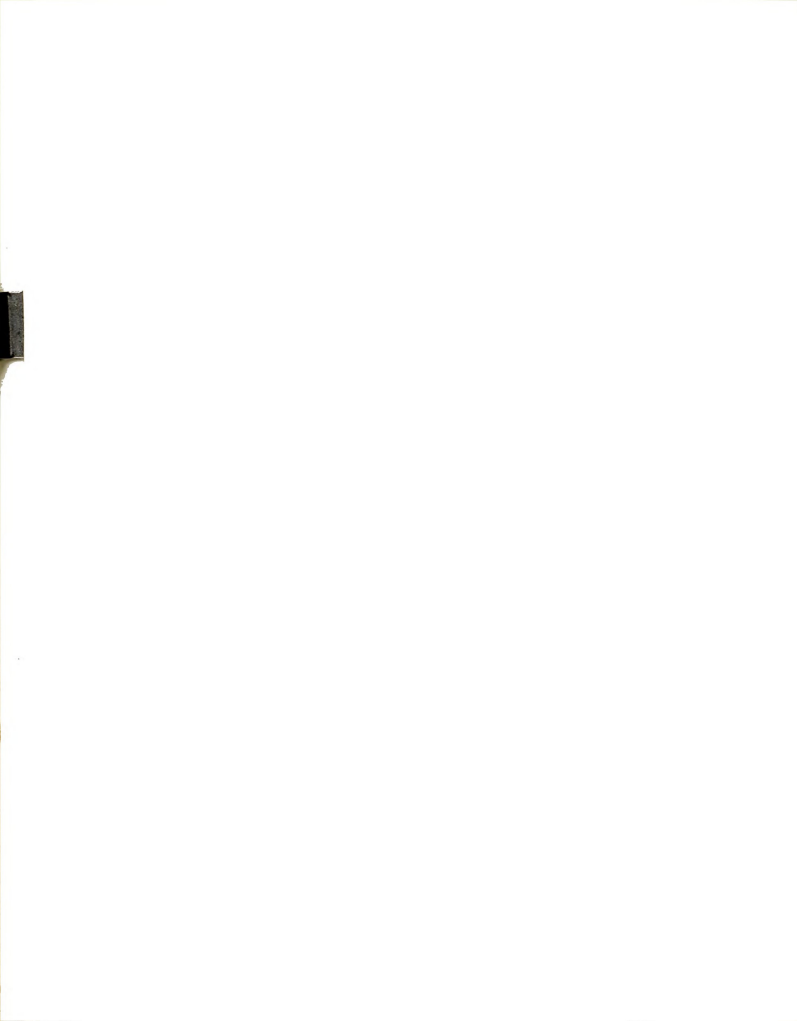
	Page
INTRODUCTION	1
Iconic Storage: Background for the Recognition vs. Recall Problem	1
Short-term Memory: Further Background for the Problem	2
Retrieval: Central vs. Peripheral	6
The Problem: Recognition and Recall Processing Defined.	9
Earlier Conceptions of Recall-Recognition Differences Reviewed	10
Derivation of Present Method	15
A Final Note	22
EXPERIMENT I--METHOD	24
Subjects.	24
Apparatus	24
Materials	25
Experimental Design	26
Procedure	27
Experimental Hypotheses.	31
Predictions.	31
Scoring Procedure.	33
RESULTS.	39
Frequency Data.	39
Learning: Change in Accuracy Scored from Trial 2 to Trial 4.	45
Perceptual Bias: Reproduction 4 Scored for Accuracy with Reproduction 2 as Standard (4 on 2) and the Original Pattern as Standard (4 on 0)	48
Retention	54
Storage	56
Perceptual Bias--Retention Profiles.	61

	Page
Learning-Retention Profiles: Second Reproduction, Fourth Reproduction and 24-hour Reproduction, All Scored with the Original Patterns as Scoring Standards	62
Summary	72
DISCUSSION.	75
Frequency of Recall--A Function of Retrieval Differences	76
Frequency of Recognition: A Function of Motivation and Signal Strength.	77
Implications for Educators.	81
Individual Patterns and Pre-Post Differences: Effects on Information Selection	82
Repetition Enhancement	90
Perceptual Bias	91
Model II: A Final Attempt to Pull Together the Many Concepts Relevant to Differentiating Recognition and Recall Processing.	94
Model IIa: Applying Model II to Explain Differ- ences in Pre- and Post-Stimulus Instructions	100
Model IIb: Applying Model II to Explain Differ- ences Between Easy (Set 1) and Difficult (Set 2) Patterns	102
EXPERIMENT II--METHOD	104
Subjects.	104
Apparatus	104
Procedure	104
Experimental Hypotheses.	105
RESULTS.	111
DISCUSSION.	115
Verbal Coding	115
Conclusions.	119
REFERENCES.	121
APPENDICES	
Appendix	
A. Assumptions of the Model	125
B. Materials	145
C. Additional Statistical Information.	148

LIST OF TABLES

Table	Page
1. Mean Number of Patterns Recalled and Recognized at Test, with Pre-Stimulus and Post-Stimulus Instructions, for Each of Two Sets of Three Patterns, Under Two Acquisition Conditions	42
1Sa. Acquired Under Recall	43
1Sb. Acquired Under Recognition	43
2Sa. Analysis of Variance	47
2Sb. Analysis of Variance	47
3. Mean Accuracy Scores for 2nd and 4th Reproductions of Pattern Sets 1 and 2, Under Pre- and Post-Stimulus Instructions, Using the Original Pattern as Scoring Standard.	49
3S. Analysis of Variance	49
4. Mean Accuracy Score for 4th Reproduction, Pattern Sets 1 and 2 Under Pre- and Post-Stimulus Instruction, Using the 2nd Reproduction (2) and the Original Pattern (0) as Scoring Standards	53
4S. Analysis of Variance	53
5. Accuracy Scores on 24-Hour Reproductions for Each Pattern, for Pre- and Post-Stimulus Instructions, Using the Original Pattern and the 4th Reproduction as Scoring Standards.	63
5S. Analysis of Variance	64

Table	Page
6. A Comparison of Mean Accuracy Scores for Mean Pattern on the 24-Hour Test, Scored with the Original Pattern (O) and 4th Reproduction (4) as Standards	66
7. Accuracy Score for 2nd and 4th Reproduction, and 24-Hour Reproduction Under Pre/Post Instructions, Using the Original Pattern as the Scoring Standard	68
7S. Analysis of Variance.	69
1Ca. Accuracy Scores for Second and Fourth Reproductions of Each Pattern Under Pre/Post-Stimulus Instructions, Using the Original Pattern as the Scoring Standard . .	148
1CaS. Analysis of Variance.	149
1Cb. Accuracy Score for Fourth Reproduction of Each Pattern, Under Pre/Post-Stimulus Instructions, Using the Second Reproduction and the Original Pattern (Indicated as 2 and 0 in the Table) as Scoring Standards . .	151
1CbS. Analysis of Variance.	152
2C. 2x2x2 Analysis of Variance for Mean Accuracy Scores for 2nd and 4th Reproductions When Conducted for Each Pattern . .	154
3C. Percentage of Set 1 and Set 2 Patterns Which Were Recognized Following Recall and Non-Recall, the 24-Hour Test	156



LIST OF FIGURES

Figure	Page
1. Mean Number of Patterns Recalled and Recognized on the 24-Hour Test, with Pre-Stimulus and Post-Stimulus Instructions, for Each of Two Pattern Sets (1 and 2).	41
2. Mean Number of Patterns Recalled and Recognized on the 24-Hour Test, with Pre-Stimulus and Post-Stimulus Instructions, for Two Conditions of Acquisition, Recognition and Recall. . .	46
3. Mean Accuracy Scores for Second and Fourth Reproductions of Pattern Sets 1 and 2 Under Pre- and Post-Stimulus Instructions, Using the Original Pattern as Scoring Standard	50
4. Mean Accuracy Scores for Fourth Reproduction, Pattern Sets 1 and 2, Under Pre- and Post-Stimulus Instructions, Using the Second Reproductions and the Original Patterns as Scoring Standards	52
5. Examples of Pattern Reproductions Which Demonstrate Perserverative Encoding Errors, i.e., the S Reproduces the Pattern with Identical or Similar Errors to an Earlier Reproduction . . .	55
6. Learning and Retention Profiles: Mean Accuracy Scores for Second Reproductions, Fourth Reproductions, and 24-Hour Reproductions, Under Pre/Post-Stimulus Instructions, Using the Original Pattern as the Scoring Standard.	58

7. Perceptual Bias Profiles: Mean Accuracy Scores for Second Reproductions Using the Original Pattern as Scoring Standard, Fourth Reproductions Using the Second Reproduction as Scoring Standard, and 24-Hour Reproductions Using the Fourth Reproduction as Scoring Standard, Under Pre- and Post-Stimulus Instructions, for Each Pattern	59
8. Mean Number of Pattern Elements Reproduced After 24 Hours as a Function of the Rank of Those Elements in Verbal Descriptions of the Pattern	113
1A. Theoretical Associative Structure of <u>S</u> Who Learned Under Recall Demand Situation	144
1C. Mean Accuracy Scores on 2nd and 4th Reproductions, Using the Original Pattern as Scoring Standards for Patterns Which Were Reproduced at 24 Hours (D) and Patterns Which Were Not Reproduced at 24 Hours (DN).	155

INTRODUCTION

Iconic Storage: Background for the Recognition vs. Recall Problem

Useful techniques have been developed recently in the study of immediate and short-term memory, yielding a pool of data which is relevant to both a multi-process conception of learning and to an analysis of recognition and recall memory. Techniques introduced by Broadbent (1958) and Sperling (1960a) have demonstrated in an unequivocal manner that information could be obtained from a stimulus after the external stimulus has been terminated. These peripheral after-effects of stimulation, from which information may be obtained, have been described as the "pre-perceptual store" of raw sensory information (Turvey, 1966) and "iconic storage" (Neisser, 1966).

Sperling's method involves cueing recall after the stimulus has terminated. A cue (tone) was presented at varying delays following stimulus termination, and cues indicated that one of three rows of digits in a 3 x 5 stimulus matrix was to be read back. A hi-pitched tone cued the report of the top row, a medium-pitched tone cued the report of the middle row, and a low-pitched tone cued the report of the bottom row. Results indicated that

information from the visual display was available with little decay after 1 second. The total number of stimuli reported was similar for cued and non-cued trials, i.e., cueing did not affect the capacity of the short-term storage area: without cueing, digits were selected at random from the three rows; with cueing, however, only information from the cued row was recalled. The conclusive point of the experiment was that selective processes could alter what was remembered after the stimulus was terminated. Therefore, the information must have been in some sort of pre-perceptual storage on which the selective process (cueing the row) could act.

Short-term Memory: Further Background for the Problem

The span of apprehension, or memory span, is determined by having S repeat back a string of words, letters, nonsense syllables, digits in the order presented to them by E, etc. The largest string which S can reliably repeat is his memory span for the type of item used. One of the most reliable constants in psychology is an individual's memory span for a given type of stimulus item.

Still it is not clear how the memory span and other types of short-term memory phenomena (e.g., Peterson, 1959) fit into a theory of retention. If the information which S can repeat is available for only a certain span of time (depending on the number of items), usually a maximum of

20 seconds (Melton, 1953) the trace is generally considered to be nonstructural, i.e., an activity trace and not a memory trace (an activity trace is conceived of as reverberation of the stimulus trace in the central nervous system). Therefore, learning is not involved, i.e., there is no change in behavior from trial N to trial N + 1.

There is evidence that seems to contradict this position, i.e., which seems to indicate that the memory span paradigm may produce learning. Hebb (1961) and Melton (1963) have shown that, in a memory span experiment increased accuracy of recall results when strings are repeated several times while alternating with novel strings. Hebb's contention is that repetition in an STM paradigm increases recall by reducing the number of perceptual units ("chunks") to be remembered, i.e., by increasing the size of a perceptual unit within a string. This is consistent with Miller's (1957) theoretical postulate that the memory span is constant for any individual for the number of chunks retained. Presumably different span lengths are found for different materials, and for the same materials when repeated often enough, because the materials can be grouped into larger perceptual "chunks."

These results must be qualified, however, by the results of other studies in which certain manipulations have eliminated the repetition enhancement found by Hebb and Melton. For example, the introduction of more novel

strings between the repeated strings can eliminate the repetition effects (Melton, 1963). Also, the use of the Sperling post-stimulus cueing paradigm (which is quite similar to a memory span paradigm in the temporal relationships) produced no repetition enhancement (Turvey, 1960). Turvey displayed three rows of six digits simultaneously, with a cue to recall a particular row presented at varying delays. One slide was repeated every other trial, alternating with a non-repeat series. There was no enhancement of recall accuracy for the repeated slide.

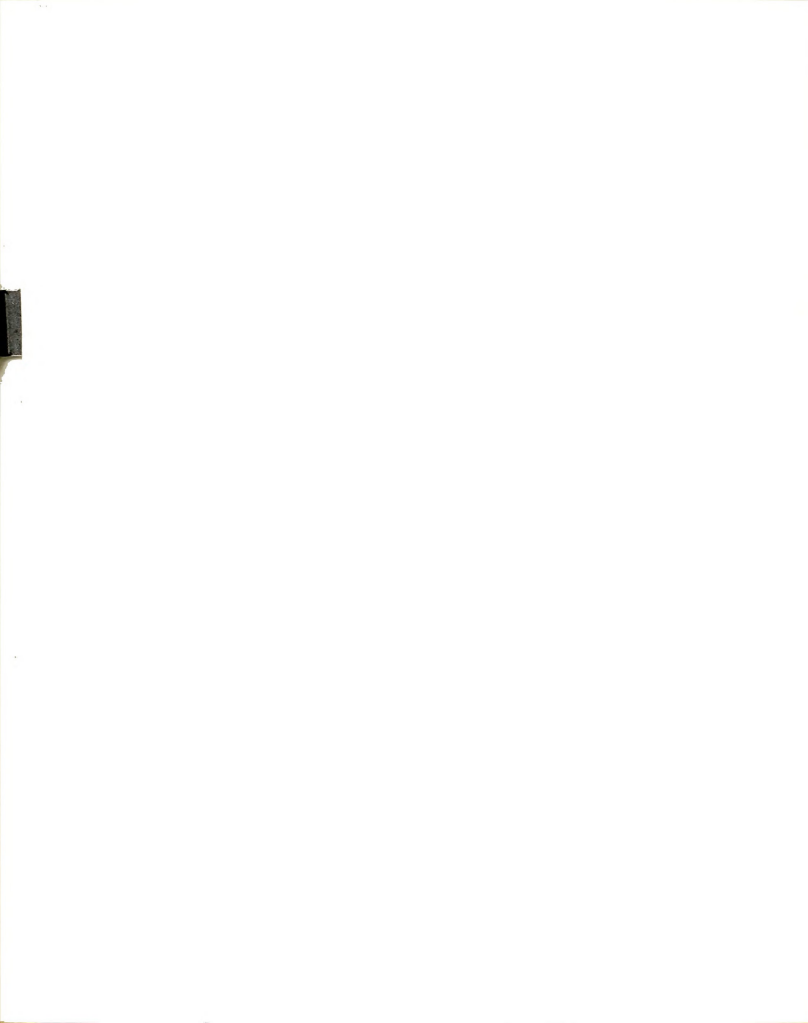
A theoretical position which has been offered to explain these divergent data is the interference position. Melton (1963) measured recall accuracy, as a function of the number of items per string, to evaluate the hypothesis that inter-item interference was responsible for the lack of repetition enhancement in some experiments. He found that accuracy was impaired with large strings. It has been argued that the Sperling paradigm may also contain a great deal of interference (Turvey, 1967). These arguments appear to bolster the attractiveness of inter-item interference as an explanatory concept to resolve the conflicting findings. However, Broadbent found that the similarity of potentially interfering materials (inter-string similarity) is unimportant in determining accuracy of recall in a STM paradigm (1963). He suggested that Melton's finding of decreased accuracy with larger strings, was due to the

greater time involved in repeating them back, i.e., due to the decay of the activity trace, rather than inter-item interference.

A summary and analysis of the major findings on STM follow: (1) The memory span paradigm has provided empirical evidence for the existence of a storage or processing mechanism which maintains information from a stimulus display for a short period of time. The length of the span for an individual is a function of the type of material. Furthermore, the amount of time which the material is retained is a function of the number of items per string. (2) Increasing the number of items per string decreases recall, but increasing inter-item similarity does not, suggesting that the decrease produced by longer strings is caused by the increased amount of time required to repeat the strings, rather than inter-item interference. (3) Some procedures produce learning in a memory span paradigm, i.e., repetition of strings enhances recall. (4) Other procedures do not produce enhancement with repetition, i.e., the Sperling technique.

Another attempt to explain the conflicting repetition effects was made by Turvey (1967). Turvey postulated that the hypothetical processing style for the Sperling technique, is different from that of the Peterson technique.

Sperling--Stimulus presentation (interval)--retrieval
 Peterson--Stimulus presentation-encoding (interval)--
 retrieval



This interpretation suggests that a central encoding response is not elicited in the Sperling paradigm, but is elicited in the Peterson paradigm. The essence of Turvey's argument is that encoding is the necessary and sufficient condition which accounts for learning in a memory span experiment. Turvey said nothing concerning the nature of retrieval of encoded information as compared with retrieval of non-encoded information, implying that the nature of retrieval is not critical to the problem. The present thesis will attempt to demonstrate that to the contrary the nature of retrieval is critical and more specifically, that only a procedure which allows retrieval of encoded information will produce learning in a memory span experiment. Whether or not this prediction is supported, it is necessary to determine if retrieval of encoded information differs from retrieval of non-encoded information. If they are different, then Turvey's analysis is incomplete.

Retrieval: Central vs. Peripheral

Turvey (1966) has suggested that the act of retrieving visual information from pre-perceptual visual store (i.e., peripheral retrieval) transforms that information, via a speech-motor code, to a form that may interfere with information that has been encoded. That is, the transformed information may affect central retrieval. According to Turvey's analysis, the encoded information is placed in auditory post-perceptual storage. The

transformation of raw visual information to encoded (auditory post-perceptual) information is mediated by the speech-motor code. Since the speech-motor code is activated during retrieval of information in visual pre-perceptual store, the act of peripheral retrieval itself must result in the encoding of the retrieved information. Therefore, Turvey's hypothesis that the Sperling paradigm did not allow encoding and that this accounted for the lack of repetition enhancement is inconsistent with his own model (1966).

The Turvey model does not conflict with earlier models of response-produced cues (e.g., Mandler, 1954). That is, the speech-motor code which transforms raw visual information to encoded auditory information is comparable in function to a verbal response-produced cue. Substituting Mandler's (1954) terminology of response factors for Turvey's processing terminology, we can arrive at the following: An implicit verbal response (R_s) is elicited by a visual stimulus or pre-perceptual stimulus trace. The verbal response produces an auditory stimulus trace (response-produced cue). Information which was earlier encoded verbally may now be re-circulated through the system via verbal rehearsal. The auditory cues from the two sources may conflict, depending upon the degree of formal similarity between the two.



Turvey and other researchers (e.g., Wickelgren, 1965) have postulated that information in short-term storage has been encoded into auditory information. Since the auditory trace may be response-produced and since humans have a strong habit of differentiating their environment verbally, it seems reasonable to assume that information in short-term storage is likely to be auditory. The retrieval of this encoded information would involve the central elicitation of the verbal (or motor) response. Thus, a central, response-produced cue must be transformed into verbal or motor output. The same type of mediating activity that was required to transform the sensory information (input) to central information (storage) must now transform the central information to sensory information (output). The reversal of the coding process, which enables a S to retrieve central information, is known as decoding.

An alternative hypothesis is offered to account for conflicting results from studies on repetition enhancement. With the Sperling technique, the brevity of the stimulus trace availability, combined with the instructions to verbally report what is visually available, may decrease the likelihood that decoding of the encoded information will occur. The logic behind this deduction is as follows:

(a) If a task explicitly asks for retrieval of information from peripheral storage (such as instructions to report what is seen), encoding will occur simultaneously with

retrieval (since the act of peripheral retrieval activates the speech-motor encoding process). Clearly, decoding, i.e., central retrieval, must follow encoding; and hence decoding is minimized by a procedure which delays encoding until the verbal report of the items. This delay prevents encoding prior to the recall test and assures that the test will measure only peripheral retrieval. (b) Since decoding, or central retrieval, is not likely using the Sperling technique the information which goes into central storage during peripheral retrieval is never retrieved.

The following conclusions were arrived at from consideration of the above discussion: (1) Peripheral retrieval necessarily activates an encoding process. (2) Given the temporal restrictions and instructions used in the Turvey application of post-stimulus cueing, decoding activity could not occur and the lack of decoding was responsible for the lack of repetition enhancement.

The Problem: Recognition and Recall Processing Defined

The distinction between a recognition measure of retention and a recall measure of retention is presumably related to the two categories of retrieval discussed. The processing required of an individual for a recognition test of retention (either short-term or long-term) involves the retrieval of peripheral information and will, in most circumstances, involve encoding but not decoding. The processing required for



recall test of retention involves the retrieval of central information and hence demands decoding. This suggests that the Peterson procedure produces a recall demand, while the Sperling procedure does not. This interpretation stresses the importance of the effects of demands upon learning processes. That is, information may be processed in different ways, depending upon the demands of the task or situation. Thus, in the Turvey experiment, encoded information may have been available in central storage following peripheral retrieval, but the demands of the experiment did not require that this central information be retrieved.

The present thesis is concerned with the implicit demands of a retention task and the effects these demands have upon learning. The thesis takes the viewpoint that the retention demands of a recall task are very different from those of a recognition task, with the recognition demand being less effective for learning. This viewpoint assumes that ss are completely familiar with the two types of test for retention.

Earlier Conceptions of Recall-Recognition Differences Reviewed

Recall and recognition as tests of associative strength. Postman, Jenkins, and Postman (1948), in their experimental analysis of errors and retention in both recall and recognitions tests, concluded that recognition and recall measures reflect the same learning processes.

Their conclusions were based on the finding that recognition following recall was poorer than recognition before recall, but recall was better following recognition than before. This order by test interaction was interpreted as indicating that weak associations could be measured on recognition tests, and that the act of measurement could reinforce the association and hence improve recall. Furthermore, recall could not measure weak associations, and, since the act of recall required time, there was greater opportunity for forgetting, hence poorer performance on recognition following recall. Other evidence cited was the predictability of recognition accuracy from recall accuracy, without the reverse being true. A model which says that recognition is a more sensitive measure of the same memory trace measured by recall, would predict this.

The demands in the Postman et al. study could not have affected processing since Ss did not know what form the retention test would take. Furthermore, the acquisition of information in the Postman et al. experiment was passive, i.e., E simply read the nonsense syllables to the college student Ss four times in different orders. There is no reason to expect that different retrieval activity was elicited during acquisition as a function of the mode of testing on the following day, or that retrieval processes for the nonsense syllables were affected in any way. In the present experiment, for information acquired passively



without knowledge of the testing condition, results should be similar to Postman's, i.e., a highly significant difference between the two measures is predicted. This need not be interpreted as indicating, in either case, that one test is simply more sensitive than the other. In fact, the recognition test was similar to the recognition acquisition procedure in the Postman et al. study, and that is why performance was good.

The recall test in the Postman study asked for information to be retrieved from the (S's) central system. The information had not been retrieved from the central system before in any systematic way, and from this perspective it is not surprising that the differences between the recognition and recall measures were so great. It would be surprising if two measures of the same process differed in sensitivity as much as the data in the Postman et al. study suggested.

Recall and recognition as differences in information content. Davis, Sutherland, and Judd (1961) hypothesized that recognition and recall might reflect a difference in the number of alternatives from which a correct item must be selected. If so, a formula which estimates information content of a decision would take this into account. In their experiment, the number of alternatives in the recall condition was finite (90), because Ss were given the rule for generating the items. There were three conditions of



recognition, with 30, 60, and 90 alternatives. The results showed no consistent differences in information content between the recognition and recall tests.

The authors pointed out that, in spite of no differences in information content, there were significantly more responses under recognition with 90 alternatives than under recall. This seemed to point out a basic processing difference, supporting the present position.

The present author does not consider the concept of information to be as useful as a multi-process conception of memory in explaining recall and recognition performance. To the extent that the Davis et al. study succeeded, it did so simply by providing a retrieval scheme which fit the Ss' existing organizational and retrieval processes. According to the present analysis, the retrieval process is different and independent from encoding. Providing the retrieval system for the recall test should eliminate all differences between recognition, except for differences in information required for the recognition decision. This does not imply that recall and recognition differences only reflect the information in a decision. If a retrieval system is not provided for the recall test, the present position would predict that differences other than information differences would be found. The dual-process interpretation, which accounts for these differences, is presented below.



Recall and recognition as independent processes.

Recent research has provided evidence which conflicts with the conclusion that recognition and recall are just different measures of the same memory unit with recall being a higher threshold measure (Postman et al., 1948; Bahrick & Bahrick, 1964). It has been shown, for example, that a more common word is recalled better (Hall, 1954), while a less common word is recognized better (Shephard, 1967). This suggests that the recognition memory process is fundamentally different from the recall memory process.

Estes and DaPolito (1967) designed a study to evaluate the hypothesis that retrieval processes are unimportant in recognition, but important in recall. They used incidental and intentional instructions, assuming that the intentional instructions would facilitate rehearsal. The results showed that intentional recall was better than incidental recall, while this difference did not hold for recognition. If, as they assume, the intentional instruction facilitates rehearsal, then the retrieval activity occurring during rehearsal facilitated recall performance, but did not affect recognition performance. It appears from this finding that retrieval processes do not affect recognition, but do affect recall. However, it is not clear from these results that the intentional instructions affected only retrieval processes. The effects of intentional instruction may include selection,

reorganization, and the use of mnemonics (i.e., the encoding scheme) as well as retrieval.

The Estes and DaPolito study provides the strongest evidence to date for the hypothesis that recall and recognition memory are independent processes. The present research will attempt to provide additional support for this notion. In addition, we hope to separate the motivational effects that an intentional recall demand has on encoding processes from the more direct effects of retrieval. This distinction between the motivational effects and retrieval effects would suggest that the dual-process theory, which assumes that recall responses are retrieved and then recognized as appropriate or inappropriate (Muller, 1913; Peterson, 1967), is probably not adequate to completely describe the differences between recognition and recall memory.

Derivation of Present Method

The instructions of the Sperling experiment do not suggest that any long-term test of memory will be given. Thus, there was no underlying evaluation of the S's ability to retain information for an extended length of time. This raises an interesting question: Could enhancement effects, not found by Turvey, be produced by changing the demands of the task? For example, if the task was defined to Ss as a test of memory and if Ss were told that some items would be repeated, a change in the Ss' responding might produce



enhancement. Another question concerning the relationship of the demands of a task to the processing style is relevant to the present interest in recognition and recall differences: Would Turvey have found a repetition enhancement if he had introduced a recognition test of memory following the experiment? Since the above analysis suggests that the information was encoded during the Turvey experiment, a procedure which did not require decoding, that is, a procedure which required peripheral retrieval, should show the effects of practice on a test of peripheral retrieval.

Questions concerning (a) the effects of the demands of a recognition as compared to a recall task, and (b) the effect of peripheral and central retrieval of information, have been brought up in the above discussion. A systematic analysis of these problems would require an experimental design in which (1) the recall and the recognition demands were manipulated, while (2) central and peripheral retrieval were manipulated, with demands counter-balanced.

The analytic advantages of the Sperling and Peterson procedures were considered in devising an experimental procedure which would accomplish the goals (a and b) mentioned above. As in the Sperling and Turvey experiments, the task will be defined to Ss as a perceptual task intended to measure the duration of images. This will be done to minimize the possibility that S will interpret the task as a measurement of his intelligence or ability to



remember. Thus, the demands specific to recognition and recall processing should be more effective.

It should be clear that the acquisition of responses to differentiate items in a stimulus array is closely related to encoding. Encoding is defined here as the transformation of sensory information to response-produced information. Mediation learning involves the association of responses (implicit or explicit) to internal (response-produced) cues. Therefore, storage activity, which involves activation of implicit responses by response-produced cues, depends upon mediation learning, as well as differential learning. Decoding requires activation of a differential response by a central-cue; i.e., selective responding from an array of internal stimuli instead of external stimuli. Since the Sperling paradigm requires the use of already differentiated materials, it cannot be used in studying differential learning. Therefore, a technique was devised which maintains the analytic advantages of the Sperling technique and can be used with undifferentiated materials. The Sperling post-stimulus cueing procedure maximizes the probability of peripheral retrieval rather than central retrieval of information. The present design will use a recognition instruction to accomplish this, i.e., when peripheral retrieval is desired. The recognition instruction will be presented before stimulus presentation (pre-stimulus) for some Ss, and five seconds after stimulus presentation for others (post-stimulus).

The recognition instruction will be given before stimulus presentation to indicate to Ss that peripheral information will be provided during the retention test and hence discourage rehearsal during the interval. In the Peterson method, central retrieval was required by using retention intervals greater than the duration of the pre-perceptual trace, in conjunction with a recall measure of retention. The present design will use a recall instruction in conjunction with a 5-second interval to accomplish this. The recall instruction will also be presented before and 5 seconds after stimulus presentation.

The effects of post-stimulus instruction should reflect the effects of a recall or recognition demand on only mediational responding, since the selection of peripheral information has already occurred.

The effects of pre-stimulus instructions should reflect the effects of recall and recognition demands on both differential and mediational responding.

A review of the major premises of the design may clarify some ambiguities. If the stimulus and pre-perceptual trace have terminated before the instructions are presented, the instructions could affect only mediational responding. If the instructions came before stimulus presentation, they could affect both differential responding and mediational responding. Another way to say this is as follows: a differential response selectively



determines which cues will be available for processing: thus a pre-stimulus instruction can affect the differential response, and hence determine which cues arrive for processing. Post-iconic instructions can affect how the cues are processed or stored, i.e., mediational responding, but not which cues arrive for processing.

A model of response factors is presented below. This model attempts to demonstrate the difference in processing which is produced by a recognition as compared to a recall acquisition situation (demand), i.e., a situation in which the S is preparing for a recognition or recall test. (In Appendix A a more detailed model of the storage and retrieval processes related to these two acquisition processes is presented.) From this model and the above discussion, experimental hypotheses were derived. These are presented following the METHOD section. The assumptions of the Model follow:

I. A recall procedure in a short-term memory task involves retrieval from both peripheral and central systems. Encoding occurs intentionally prior to retrieval and hence the act of retrieval sets up a decoding scheme which results from selective processes acting upon central as well as peripheral information.

II. Availability of information for retrieval is an increasing function of the activation of retrieval from the central system. Thus decoding, which can be described

in the present framework as the Rs_I -- Rs link, is considered to be the critical factor in differentiating a recall from a recognition measure of retention.

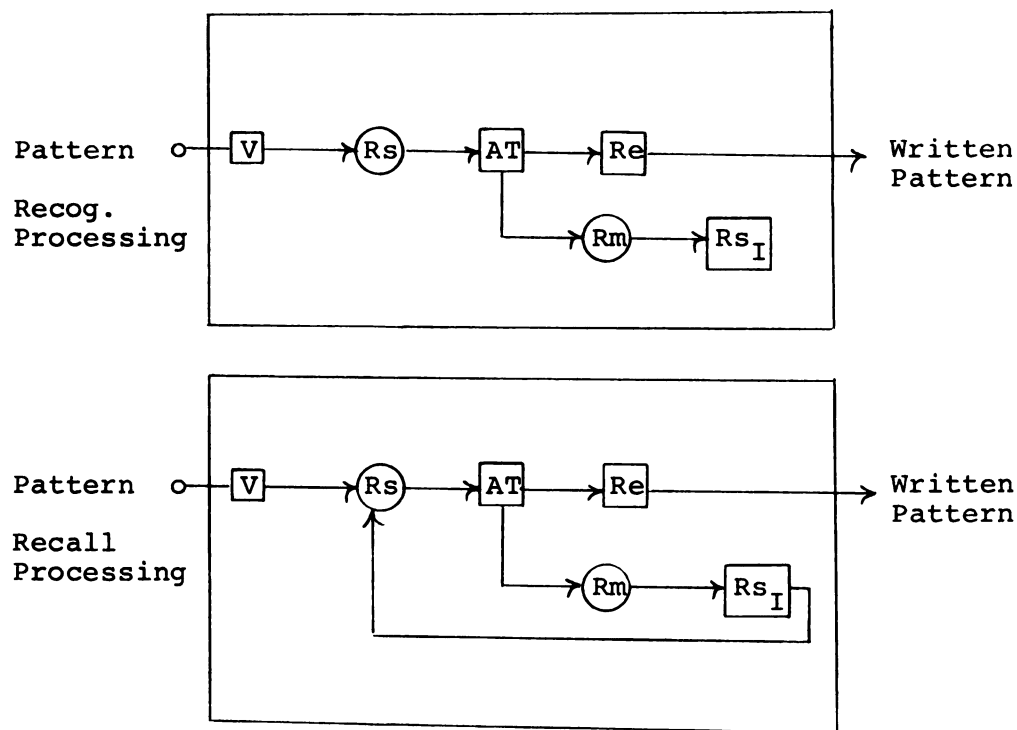
III. A recognition acquisition procedure involves retrieval from the visual system without intentional prior encoding. (It is assumed that random encoding may occur as a function of pattern differences and subject differences.) Intentional encoding is activated simultaneously with peripheral retrieval, and hence central information is stored, but not retrieved, on a recognition test.

IV. The temporal delay of instructions (post-stimulus condition) will decrease the specificity of any processing, and will increase the encoding in the recognition acquisition procedure. This is due to the increased uncertainty of the demands of the task, i.e., anticipation of possible instructions to recall would increase encoding.¹

The processing diagram below represents the critical differences described in Model I, between short-term memory processing for a recall and a recognition task.

¹The theoretical assumptions underlying these postulates are described in more detail in Appendix A.





Definitions

Rs--Selective responding: determines what information in what order will be taken from the visual system.

AT--Activity Trace: central reverberation of Rs-produced information is assumed to last for several seconds. This is the STM of encoded information.

Rm--Central associative activity activated by RS-produced information. This activity determines the storage parameters of the information.

R_{SI} --Information produced by Rs, and integrated into an Rm aggregate. The operational distinction between



encoding and decoding is that the R_S response is elicited by an R_{SI} in decoding, i.e., information is being retrieved from central storage, while in encoding, the R_S response is elicited by a peripheral cue.

Re--Effector response--this represents the necessary translation component to get information out of the system.

A Final Note

Much of the work done with verbal materials is difficult to evaluate if the aim of that evaluation is to determine which skills or processes enable the S to recall an item. The difficulty is based primarily on the confounded nature of the S 's prior learning of the materials. With college S s, verbal responses have been overlearned. This is true at every level of analysis, from phonemes, to letters, to words, to syntactical combinations. The effect of this overlearning can only be conjectured, but it is obvious that differential responses, as discussed above, will be greatly affected by transfer of prior learning. Transfer of highly overlearned verbal responses is a relatively unresearched phenomenon (Mandler, 1954) and hence very difficult to control effectively.

Experiment I, therefore, attempts to investigate the effects of a recall demand and a recognition demand on differential and mediational learning by comparing the

effects of a recognition versus a recall procedure of acquisition, on both STM and LTM performance, using relatively unfamiliar visual patterns. The materials were chosen to minimize previous differential learning, i.e., to minimize prior experience with the materials, and also to minimize prior associative learning which might confound the results. It was hoped that the effects of recall and recognition demands upon the acquisition phase of learning might be observed with little interference from transfer of prior learning.

Experiment II attempts to evaluate the relative success of the use of non-verbal materials. That is, an attempt is made to assess the extent of verbal coding used by Ss with the unfamiliar visual patterns used in Experiment I.

EXPERIMENT I

METHOD

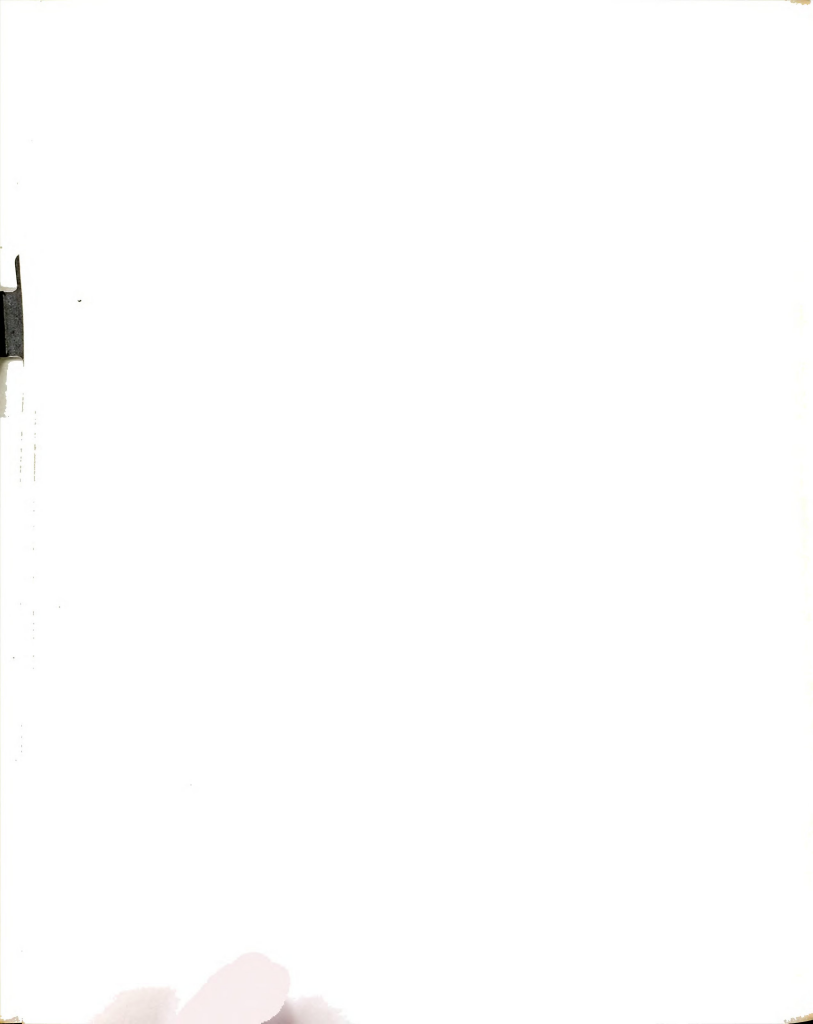
Subjects

The Ss were 100 volunteers from the introductory psychology course at Michigan State University who participated for extra credit. They were randomly assigned to 4 Groups with 25 Ss in each Group. The majority of these Ss were college freshmen.

Room: The projection room was a small, rectangular room approximately 6' x 15' which was used as a laboratory for classes in perception. From 8-12 Ss were seated in three rows of four seats. The seats were closely grouped, so the nearest row was 4 ft. from the screen, while the furthest row was approximately 10 ft. from the screen.

Apparatus

The patterns were photographed for 35-mm slides and projected on a 2' x 2' screen with a Kodak slide projector (Carousel) in a semi-darkened room. The timing of slide exposures was controlled by the automatic advance device on the projector (approximately .5 seconds).



Materials

The materials were patterns of black squares on a white background. In a 5" x 5" field, each of the 25 1" squares was numerically coded according to the following scheme: first number indicated the square's position in a left-to-right horizontal field; second number indicated the square's position in the top-to-bottom vertical field. Eight 2-number combinations were chosen for each pattern without replacement from a table of random numbers. Twenty-five eight-square patterns in all were generated in this manner. From these 25, six pairs of patterns were chosen as mates for the recognition test. The mates were matched for form similarity on the basis of an initial scoring formula. Six of the 12 patterns were presented during the acquisition series. The other six, matched for similarity, were alternatives on the 24-hour recognition test trial. The six patterns presented during acquisition were divided into pattern set 1 and pattern set 2. This was done to enable counter-balancing of specific patterns across all conditions. The original patterns were drawn with India ink on white posterboard backing. They were then photographed, and color slides made to maximize the black-white contrast. Drawings of the 12 patterns (six pairs) can be seen in Appendix B.

Experimental Design

The present experiment used a mixed 2x2x2x2 design. (Immediate test by long-term test by instruction by pattern sets.) All Ss were given immediate recall tests for half of the patterns presented to them on day 1 and immediate recognition tests for the other patterns. In addition all Ss were given both a 24-hour recall test, and a 24-hour recognition test, for retention of all patterns seen. Ss in Groups 1 and 3 received a pre-stimulus instruction during acquisition, while Ss in Groups 2 and 4 received a post-stimulus instruction. Groups 1 and 2 had to recall set 1 patterns and recognize set 2 patterns, while the reverse was true for Groups 3 and 4. Thus, each pattern was acquired under each condition, i.e., information content was counter-balanced across subjects.

Repetition: Presentation of the six patterns constituted a trial. There were four trials, and the order of presentation within each trial was randomized. Ss were not told that any patterns would appear more than once, and questioning of Ss after the 24-hour test indicated that most Ss were not aware of the repetition.

Post-stimulus cueing: The purpose of the Post-Stimulus Condition was to evaluate the effects of central retrieval versus peripheral retrieval of visual information in a STM task upon the availability of information for a LTM test.

An attempt was made to control, or at least attenuate, the effects of instruction on information selection by presenting the instruction to recall or recognize 5 seconds after pattern presentation.

Procedure

Groups of Ss arrived at the experimental room at a prearranged time. E seated S and gave each S a data sheet. E then read the following instructions to Ss.

Instructions: "You will be shown a series of patterns of black squares on a white background. We are investigating the ability of humans to maintain the image of a visual pattern. The patterns will appear only briefly, so you must concentrate to see them. For 5 seconds following the termination of the pattern, try to maintain the image while continuing to look at the screen." Ss were then told the procedure for a recognition trial and for a recall trial, as follows:

Recognition: "If I say 'Select it' at the end of the 5 seconds, you will be provided with three alternatives from which you must select the pattern you have seen. After selecting the pattern, you are to trace over the X's in the pattern with back of your pencil, then place the number indicating the position of the pattern in the spaces in the upper left corner. Are there any questions?"

Recall: "If I saw 'Draw it' at the end of the 5 seconds, you are to fill in the X's on the portions of the grid which you wish to designate as part of the pattern. Are there any questions?"

Immediate Memory Series: The presentation of each slide was activated by a hand switch. The pattern was flashed for approximately 500 msec., followed by a 5-second blank field with the same intensity of illumination as the pre-stimulus field. The E activated the hand switch, always telling the Ss just prior to the activation, "Here is the next pattern."

Data sheets: Reproductions were drawn in one of the three empty grids across the top of the data sheet. There were three patterns across the bottom of the data sheet, from which S had to select one. On a recognition trial, S would write the number of the position of the pattern (1, 2, or 3) in the space provided in the upper left portion of the data sheet. (See Appendix B for a sample data sheet.)

On both recall and recognition trials, Ss were urged to close the cover sheet immediately upon completion of the task. It was stressed that the time spent with each pattern should be no more than the duration of the task; i.e., S was not allowed to examine the sheet following the completion of the drawing or selection.

24-hour test: Since Ss were told that the purpose of the experiment was to study visual memory of unfamiliar material, they should not have been aware that they were to be tested on anything for the second session. They were returning ostensibly to participate in a second experiment.

When Ss arrived at the second session, E first instructed them: "Produce any correct pattern which you can recall from yesterday's series. Only six correct patterns were presented, four times each, during yesterday's series, three of which you were to recall, three of which you were to select from three alternatives." Five minutes after Ss had completed the recall test, E presented Ss with a series of 12 patterns. E explained that only six were correct (i.e., were seen yesterday) and six were incorrect (i.e., were not seen the previous day). E told the Ss to select the six correct patterns from the previous day. They were then to write the number of the patterns in the blanks provided.

The Ss were then asked if they had anticipated during the first session that they might be tested later for retention of the patterns.²

Pre-stimulus cueing: The purpose of the Pre-Stimulus condition was to evaluate the additional effects associated

²No S suspected that he would be tested later.

with S's knowing that he was to be tested with a recall versus a recognition test. Therefore, Ss were told how they would be tested prior to stimulus presentation.

Procedure

The procedure was identical to the Post-Stimulus procedure except E told S whether a pattern was to be recalled or recognized in the immediate memory test before the pattern was presented. Thus, E would say, "Here is the next pattern, you will have to draw it," or "Here is the next pattern, you will have to select it from three alternatives." Except for this the instructions were identical to those for the Post-Stimulus procedure.

Immediate Memory-Series: All manipulations were identical to the post-stimulus procedure, except that Ss were told, before each slide, whether the pattern was to be produced or recognized. As in the post-stimulus cueing procedure, the information content of the patterns was counter-balanced for the (Recognition-Recall) retention mode.

24-hour test: The procedure and instructions for the 24-hour test were identical to the post-stimulus condition. As in the post-stimulus condition, Ss were unaware that they were being retested on a second day.

Experimental Hypotheses

Several hypotheses about performance on retention tests following a recall or recognition acquisition procedure were derived from the discussion above and from the model presented in Appendix A. The predictions below concern (a) the scoring of 5-second reproductions with the standard (i.e., the original pattern); (b) the scoring of 24-hour reproductions with 5-second reproductions; (c) the scoring of the 24-hour reproductions with the standard; (d) the comparison of percentage of patterns recalled at 24 hours when the patterns were acquired with a recognition procedure and with a recall procedure.

Predictions

(a) The scoring of 5-second reproductions with the standard. Pre-stimulus instructions influence differential responding, and hence, the demand imposed by the recognition or recall instruction will influence both differential and mediational responding. Post-stimulus instructions should not influence differential responding to the visual image, since the image fades completely in 5 seconds (Sperling, 1960a). Therefore, the demand can influence only mediational responding.

Specifically, any increment in differential learning which is due to recall instructions will be shown in the pre-stimulus instructions condition, but not in the post-stimulus instructions condition. This increment

should be reflected by increased accuracy of the 5-second reproduction when scored with the standard, i.e., 5-second reproductions should be more accurate in the pre-stimulus condition than in the post-stimulus condition.

(b) The scoring of the 24-hour reproductions with the 5-second reproduction. It is suggested in (a) that most differential responding takes place in the first 5 seconds. Beyond these 5 seconds, storage and retrieval mechanisms will be the dominant factors in determining whether the differentiated information will undergo the effective central integration.

Therefore, both pre- and post-stimulus instructions influence central integration. If the 5-second reproduction (which should represent the extent of differential responding which occurred) is used as a standard for scoring the 24-hour reproduction, there should be no significant difference between the scores for Pre-stimulus and Post-stimulus patterns.

(c) The scoring of the 24-hour reproduction with the standard. In the pre-stimulus condition, the demand imposed by the instructions should influence both perceptual and central integration. In the post-stimulus condition, the demand should influence only central integration. Therefore, for Groups 2 and 4, the 5-second reproductions will be less accurate and hence, the 24-hour reproduction will be less accurate, when compared with the

standard. This prediction is an obvious consequence of predictions (a) and (b). For Groups 1 and 2, the 5-second reproductions should be more accurate, and hence so should the 24-hour reproduction.

(d) The comparison of percent recalled of patterns acquired under recognition and recall instructions. It is postulated that the act of reproducing the pattern at 5 seconds is likely to activate differential responding to central cues which will facilitate decoding. The recognition procedure is likely to activate only a minimal differential response to peripheral cues which will not facilitate decoding. Those patterns which are acquired under a 5-second reproduction procedure (recall instructions) will be recalled more frequently in all conditions.

Scoring Procedure

The scoring procedure which was adopted was a modification of the intended procedure. The modification became necessary due to the practical problems in the original procedure. The modified procedure employed an information measure, by checking for direct overlap and 90° and 45° proximity of the reproduced squares according to a pre-determined sequence. The grid of the scoring standard would be placed over the grid of the reproduced standard, and each square of the reproduced pattern which overlapped a square in the standard was given a score of

3 points. A square which received a score was then deleted immediately from the reproduction. In the second scoring step (right angle proximity) the standard was shifted one square in each direction, one square away from the original position, so that any square in the reproduced pattern which was one square away--either up, down, to the right, or to the left, received a score of 2 points. Again, if a square received a score, it was deleted immediately, ensuring that no square would be scored twice. The final step was diagonal proximity. Diagonal proximity scores were obtained in a similar fashion to right angle proximity scores, except that the standard shift was one square away from the original position in each diagonal (i.e., 45°) direction. Any square which did not receive a direct overlap or right angle proximity score which was one square away in a diagonal direction (i.e., up-right, up-left, down-right, down-left) was given a score of 1-1/2.

The three scores were then added to give a total score.

Correction for guessing.

A. Correction for Excess--If the reproduced pattern contained more squares than the standard, the probability of a square being correct by chance increased. This becomes more serious as the error increases, so that a 12-square reproduction with an 8-square standard will increase the probability of a correct guess from one-third to

one-half. To correct for these more serious errors, while minimizing the penalty for small errors, the following formula was chosen: $NSUM \text{ (total score)} = NSUM - \frac{X^2}{2}$, where X = the difference between the number of squares in the scoring standard and the reproduction. The formula was chosen because it made corrections which were appropriate in the range most frequently encountered (from 9 to 12 squares).

B. Correction for Deficiency--If a reproduction contains less than the number of squares in the standard, the probability of getting a correct square by chance is correspondingly decreased. To determine the nature of this decrease in guessing, a family of 12 eight-square patterns was generated randomly, and scored by the above procedure, using each pattern as a standard for the other 11 patterns. The per-square average for these randomly scored patterns was 2.04, with a standard deviation of .07. Using 2.04 as an approximate score for a square which is added by S if he were guessing (i.e., a randomly placed square), the deficiency correction formula which was derived was quite straightforward: $NSUM = NSUM + 2.04 X$. (It should be noted that this is only defensible when the number of squares in the standard is eight. A random per square value for other size patterns (e.g., 9 or 10 squares) would undoubtedly be higher. Hence, any correction made using this figure with a scoring standard of

more than eight squares would underestimate the effects of guessing. Since the scores are compared on the basis of an eight-square model, this under-estimation is appropriate for accuracy scores comparing eight-square reproductions.)

Accuracy scores. The total score attempts to estimate the extent to which the information in the reproduced pattern as a whole differs from chance. The accuracy score goes one step further, and considers the extent to which an average square in a reproduction differs from a chance reproduction. This additional analysis is attained by dividing the corrected scores by the number of squares, thus giving a per square score which reflects the accuracy of all the squares combined in the reproduction. As was mentioned above, an approximation for the range of chance accuracy scores is from 1.90 to 2.18 at the .01 confidence level. The two corrected scores use different accuracy scores for obvious reasons.

$$\text{Excess corrected accuracy} = \frac{\text{NSUM} - X^2/2}{N}$$

where N = number of squares in the reproduction.

$$\text{Deficiency corrected accuracy} = \frac{\text{NSUM} + 2.04X}{8}$$

In both cases, a perfect score of 3.0 can only be obtained with a perfect reproduction. Excess corrected accuracy (ECA) is penalized more than deficiency corrected

accuracy (DCA). The rationale for this is as follows: a deficiency total should imply that the S is using a stricter criterion, and, hence, although fewer squares are put down, S is more sure of those which he does draw. This is supported by the fact that the "raw" accuracy scores, i.e., uncorrected scores divided by the number of squares in the reproduction, show a definite superiority for the deficiency reproductions (i.e., those with less than eight squares). While the corrections attempt to attenuate the effects of guessing, they should not eliminate the effects of this stricter subject-imposed criterion. A corresponding increase in total score should accompany the decrease in accuracy, i.e., the "hit" rate should increase along with the error rate (Kintch, 1970). The method of correction also reflects this, since the total score following correction is higher for the ECA than for the DCA. For example, a perfect reproduction with two squares extra would receive a score of 24 plus whatever value the additional two squares provided. If one of the extras was not scored, and one received 2 points, the total, uncorrected score would be 26. The correction would be $2^2 = 4/2 = 2$. Thus the corrected total would be 24, a perfect total score. The accuracy score would be divided by 10, not 8, however, and the derived accuracy score would be 2.4. A perfect reproduction with two squares missing would reflect the opposite criterion bias. The

"raw" total score would be 18, with a correction of $2(2) = 4$, i.e., the corrected score = 22. The accuracy score would be $22/8$, i.e., 2.75. Thus, the total corrected score will be higher for patterns with too many squares, and lower for those with too few squares, but the accuracy score will be the reverse.

RESULTS

Frequency Data

The number of patterns recalled at 24 hours under the various conditions was considered to be a measure of retrieval, independent of organizational or perceptual factors. In most cases, a reproduction (recalled pattern) was clearly identifiable as a specific pattern. In some cases, due to the similarity of features of the original pattern, objective identification of a reproduction required two steps. First, the reproduction was scored on both patterns, and the pattern from which the higher score was obtained was identified as the appropriate standard. Secondly, the accuracy score based on the chosen standard was computed and if it was not above 2.20 (3.0 is perfect) the pattern was discarded. Any reproduction with less than four squares was also discarded.

The number of patterns recognized and the number recalled at 24 hours were counted for the two main acquisition conditions, recall and recognition, as well as for instructions and pattern set. Thus each S had a score ranging from 0-3 for both 24-hour recognition and recall tests, as a function of each acquisition condition (since

all Ss viewed three patterns under recognition and three patterns under recall instructions). Four 2x2x2 analyses of variance with one repeated measure on the last factor were run. In the first set of analyses the three factors were pattern set (1 and 2), instructions (pre and post), and tests (recognition-recall). The analysis was done separately for patterns acquired under recognition demand and patterns acquired under a recall demand. The most important comparison refers to the effects of tests given under the two acquisition conditions (see Figure 1).

For patterns acquired under a recall demand, the difference between the recognition and recall measures at test was non-significant ($F=1.404$). ("At test" will be used in this paper to refer to the 24-hour test.) This means Ss under a recall demand recalled patterns and recognized patterns at test with about the same frequency. On the other hand, the difference at test between the recognition and recall measures for patterns acquired under a recognition demand were highly significant ($F=151.48$, $p < .001$). Patterns were recognized more frequently than recalled (see Figure 1, Tables 1, 1Sa, 1Sb).

Also for patterns acquired under a recall demand, the effect of pattern set was significant at the .001 level, with mean number of set 1 patterns being recognized (mean=2.400) and recalled (mean=1.978), significantly more often than set 2 patterns (means=1.48 and 1.68 respectively).

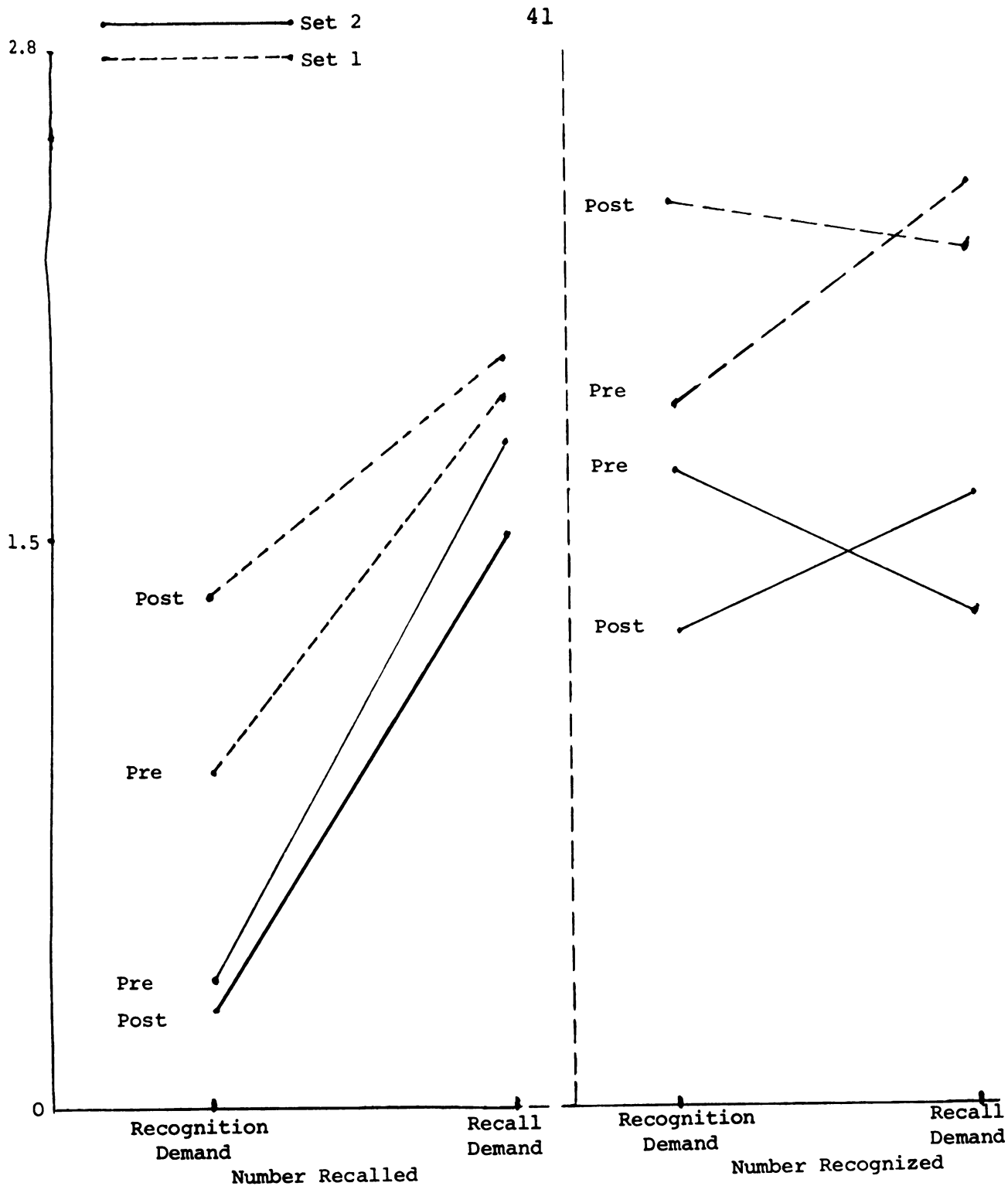


Figure 1. Mean number of patterns recalled and recognized on the 24-hour test, with pre-stimulus and post-stimulus instructions, for each of two pattern sets (1 and 2). The number recalled (left side of figure) and the number recognized (right side of figure) are plotted as a function of the demand condition during acquisition (recall and recognition).

TABLE 1

Mean Number of Patterns Recalled and Recognized at Test,
with Pre-Stimulus and Post-Stimulus Instructions,
for Each of Two Sets of Three Patterns,
under Two Acquisition Conditions

Acqui- sition	Pattern Set				Marginals	
	Set 1		Set 2			
	Number Recog.	Number Recalled	Number Recog.	Number Recalled		
Recall	Pre	2.480	1.920	1.320	1.800	Recog.=1.90 Recall=1.86
	Post	2.321	2.035	1.640	1.560	Recog.=1.98 Recall=1.797
Marginals		2.40	1.978	1.480	1.680	
Recognition	Pre	1.880	.920	1.280	.280	Recog.=1.58 Recall= .60
	Post	2.385	1.346	1.740	.370	Recog.=2.063 Recall= .858
Marginals		2.132	1.133	1.510	.325	

AOV TABLE 1Sa
(Acquired under Recall)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Total	150.07263	205		
Between (LS)	88.65049	102		
A	19.07232	1	19.07232	27.15437 ^c
B	0.00443	1	0.00443	0.00631
AB	0.04847	1	0.04847	0.06900
Error B	69.53429	99	0.79237	
Within (LS)	53.00000	103		
E	0.63790	1	0.63790	1.40410
AE	4.98286	1	4.98286	10.96786 ^b
BE	0.26212	1	0.26212	0.57986
ABE	2.23497	1	2.23497	4.91943 ^a
Error W	44.97714	99	0.45431	

TABLE 1Sb
(Acquired under Recognition)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Total	169.33982	205		
Between (LS)	91.72816	102		
A	26.29492	1	26.29492	44.90514 ^c
B	7.06106	1	7.06106	12.05852 ^c
AB	0.46348	1	0.46348	0.79150
Error B	57.97103	99	0.58557	
Within (LS)	103.50000	103		
E	61.37256	1	61.37256	151.48461 ^c
AE	0.44475	1	0.44475	1.09777
BE	0.64776	1	0.64776	1.59884
ABE	0.27399	1	0.27399	0.67629
Error W	40.10892	99	0.40154	

Factor A--Pattern Set (1 & 2); Factor B--Instructions (Pre- and Post-); Factor E--Recognition-Recall measure.

* < .05
 ** < .01
 *** < .001

The pattern set x test interaction, significant at the .01 level, indicates a larger difference between the two sets for a recognition test than for a recall test. Instructions (pre and post) showed no significant effects.

For patterns acquired under a recognition demand, all factors yielded significant effects but no significant interactions. Set 1 patterns were again recalled and recognized more frequently than set 2 patterns ($F=44.905$, $p < .001$), and patterns acquired under post-stimulus instruction were recalled and recognized more frequently than those acquired under pre-stimulus instruction ($F=12.058$, $p < .001$). As already mentioned above, the test factor was highly significant.

The critical differences noted between the recognition and recall demands were formally tested in a second analysis in which the acquisition demand condition was a factor, along with instructions and tests. A separate analysis was done for each pattern set. For pattern set 1, acquisition demand condition was highly significant ($F=20.300$, $p < .001$) as was expected from the first analysis. Tests as a factor was also significant ($F=9.769$, $p < .001$), and the significant test x demand interaction ($F=11.479$, $p < .001$) clearly showed that good recall at test required a recall demand during acquisition. Instructions was significant ($F=4.725$, $p < .05$) with the post-stimulus instruction producing higher recognition and

recall scores than pre-stimulus instructions. The instruction x demand interaction was significant ($F=5.42$, $p < .05$), reflecting a larger pre- versus post-stimulus difference under recognition demand than under recall demand. The analysis of pattern set 2 revealed even greater differences. The demand condition was highly significant ($F=40.082$, $p < .001$) as was the demand x tests interaction ($F=50.079$, $p < .001$). This highly significant interaction provides the strongest support for the argument that good recall required a recall demand. Tests as a factor was highly significant ($F=25.234$, $p < .001$), because recall was so poor under a recognition demand (see Figure 2, also Tables 1, 2Sa, and 2Sb).

Learning: Change in Accuracy Scored from Trial 2 to Trial 4³

An analysis of variance for a 2x2x2 design with repeated measures on the last factor was conducted. The factors were instructions (pre-post), pattern sets (1 and 2), and learning (the accuracy score on trial 2 versus on trial 4). There were no significant main effects for instructions, but there was a significant instruction x learning interaction ($F=5.412$, $p < .05$). This indicated a substantial increase in performance from trial 2 to trial 4

³A separate analysis of variance for each of the six patterns was carried on. The interested reader is referred to Appendix C, Table 1C.



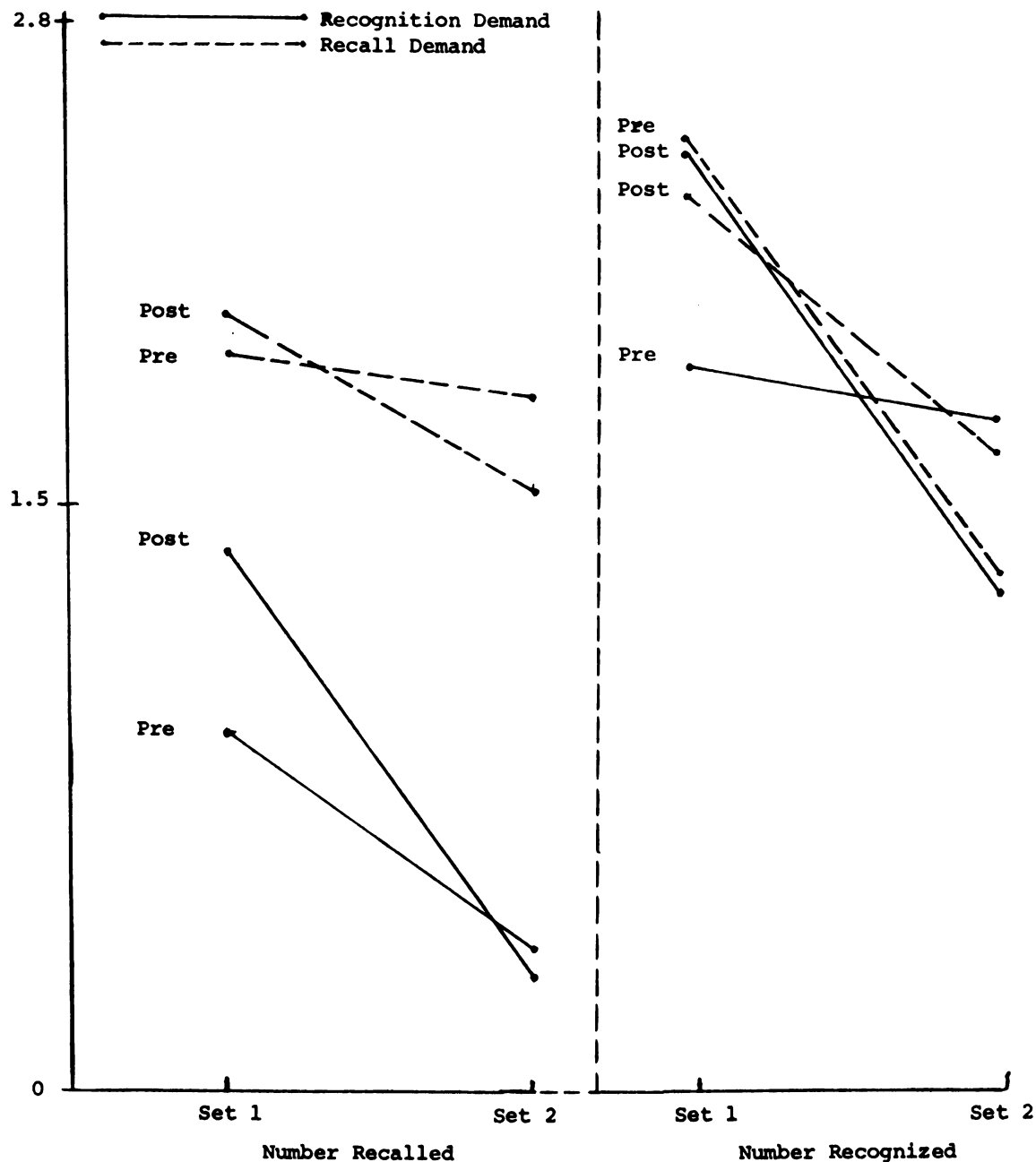


Figure 2. Mean number of patterns recalled and recognized on the 24-hour test, with pre-stimulus and post-stimulus instructions, for two conditions of acquisition, recognition and recall. The number recalled (left side of figure) and the number recognized (right side of figure) are plotted as a function of the two pattern sets (1 and 2).

AOV TABLE 2Sa

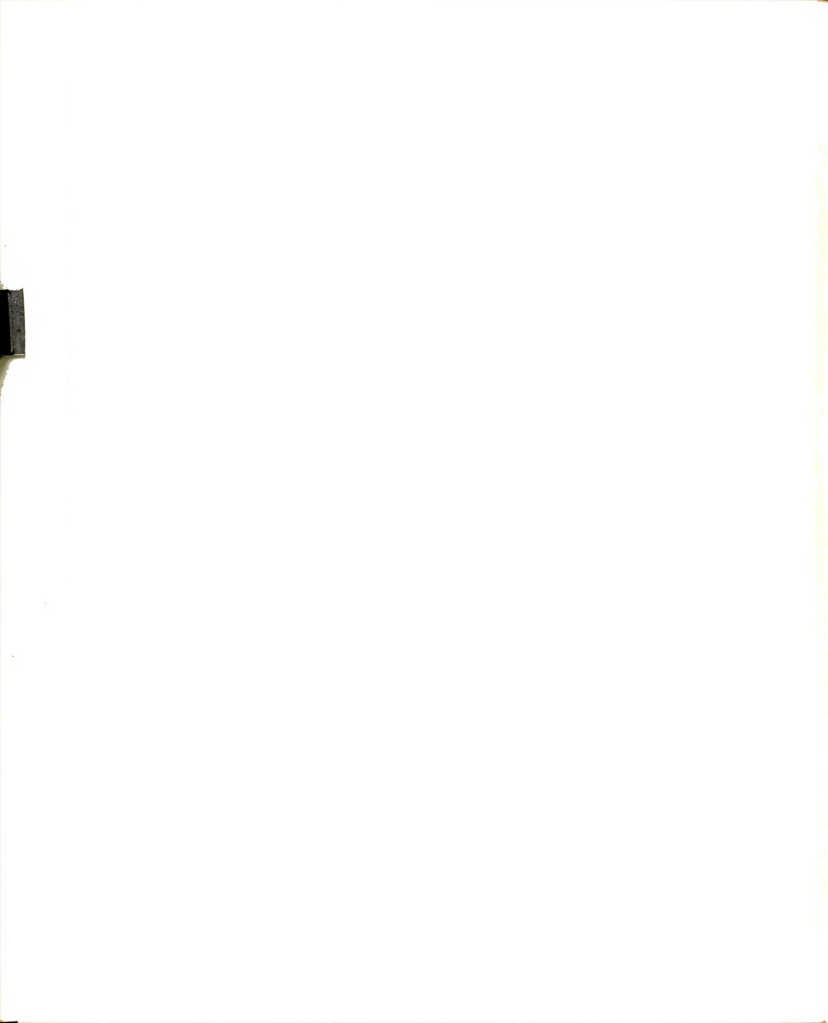
Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern Set 1				
Total	160.75961	205		
Between (LS)	88.04854	102		
A	3.19269	1	3.19269	4.72501 ^a
B	14.39269	1	14.39269	21.30041 ^c
AB	3.76516	1	3.76516	5.57224 ^a
Error B	66.89429	99	0.67570	
Within (LS)	67.00000	103		
E	26.00304	1	26.00304	69.76966 ^c
AE	0.12121	1	0.12121	0.32521
BE	4.27827	1	4.27827	11.47917 ^b
ABE	0.40304	1	0.40304	1.08141
Error W	36.89714	99	0.37270	

TABLE 2Sb

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern Set 2				
Total	169.01077	205		
Between (LS)	81.84466	102		
A	1.12317	1	1.12317	1.93959
B	23.21051	1	23.21051	40.08194 ^c
AB	0.59767	1	0.59767	1.03210
Error B	57.32857	99	0.57908	
Within (LS)	89.50000	103		
E	12.29948	1	12.29948	25.23399 ^c
AE	2.70094	1	2.70094	5.54132 ^a
BE	24.40957	1	24.40957	50.07943 ^c
ABE	0.13214	1	0.13214	0.27109
Error W	48.25429	99	0.48742	

Factor A--Instructions (Pre/Post); Factor B--Acquisition (Recog.-Recall); Factor E--Recog.-Recall Measure

* < .05
 ** < .01
 *** < .001



for the pre-stimulus condition when compared with the post-stimulus condition (mean difference of .113 for pre-stimulus; mean difference of .019 for post-stimulus; see Table 3, 3S). I.e., there was significantly more repetition enhancement under pre-stimulus than under the post-stimulus instructions.

There was a significant pattern set effect ($F=4.223$, $p < .05$) which reflected consistently higher scores for pattern set 2 than set 1. Learning occurred, i.e., the differences between scores on trial 2 and on trial 4 were significant ($F=9.108$, $p < .01$), with trial 4 showing improvement for all but the set 1--post-stimulus condition, which showed a slight decrease in accuracy on trial 4 (see Figure 3).

Perceptual Bias: Reproduction 4 Scored for Accuracy with Reproduction 2 as Standard (4 on 2) and the Original Pattern as Standard (4 on 0)

(It was assumed in present analysis that if a pattern was more similar to an earlier reproduction than to the actual pattern, a perceptual distortion or bias was intervening which tended to reinforce the memory of an earlier percept. This is the same assumption which Sheehan (1966) made, and will be discussed thoroughly below.)

An analysis of variance for a $2 \times 2 \times 2$ design with repeated measures was conducted. The repeated measure was

TABLE 3

Mean Accuracy Scores for 2nd and 4th Reproductions of
Pattern Sets 1 and 2, under Pre- and Post-Stimulus
Instructions, Using the Original Pattern as
Scoring Standard

Reproduction		
2	2.484	2.440
4	2.618	2.532
2	2.499	2.459
4	2.534	2.443
	Set 2	Set 1

TABLE 3S

Analysis of Variance

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Total	8.09916	185		
Between (LS)	4.10992	92		
A	0.06359	1	0.06359	1.46587
B	0.18320	1	0.18320	4.22306*
AB	0.00021	1	0.00021	0.00491
Error B	3.86100	89	0.04338	
Within (LS)	2.14637	93		
E	0.18682	1	0.18682	9.10323**
AE	0.11101	1	0.11101	5.41216*
BE	0.03018	1	0.03018	1.47157
ABE	0.00089	1	0.00089	0.04356
Error W	1.82549	89	0.02051	
Factor A: Instructions (Pre/Post)				
Factor B: Pattern Set (1&2)				
Factor E: Score on trial 2 and 4 (Repeated Measure)				

* < .05

** < .01

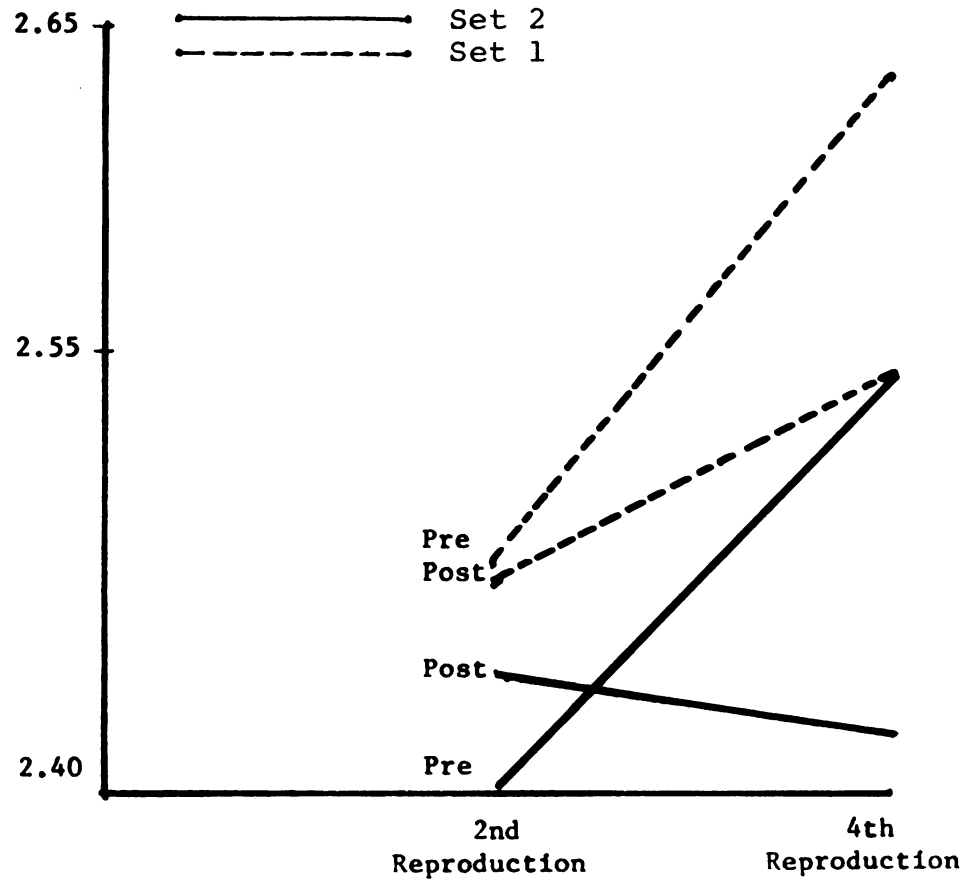


Figure 3. Mean accuracy scores for second and fourth reproductions of Pattern Sets 1 and 2 under pre- and post-stimulus instructions, using the original pattern as scoring standard.

the accuracy score on the fourth reproduction, scored with two different standards (the second reproduction [4 on 2] and the actual pattern [4 on S]). The other factors were, as above, Instructions and Pattern Set.

There was no significant instructions effect. The main effect of pattern set was weak ($F=2.849$, $p < .10$), but pattern sets showed up prominently in a highly significant pattern sets by perceptual bias interaction ($F=21.81$, $p < .001$). This interaction results from a higher 4 on 2 than 4 on 0 score for set 1, with the reverse (a higher 4 on 0 than 4 on 2) for set 2 (see Figure 4). The main effect for perceptual bias was clearly significant ($F=10.263$, $p < .01$. See Tables 4 and 4S). This means that Ss exhibited a perceptual bias when processing patterns in set 1 but not for patterns in set 2. This is consistent with the finding above that patterns in set 2 showed more learning than patterns in set 1, i.e., a perceptual bias would inhibit learning.

It has been said that a picture is worth approximately a thousand words, and since this dissertation has attempted to minimize verbal coding as an artifact, the saying is especially appropriate here. It may not be clear to the reader what is meant when a reproduction is scored by both an earlier reproduction and the original pattern, or why this was done. Several examples of actual second, fourth, and 24-hour reproductions for a particular pattern,

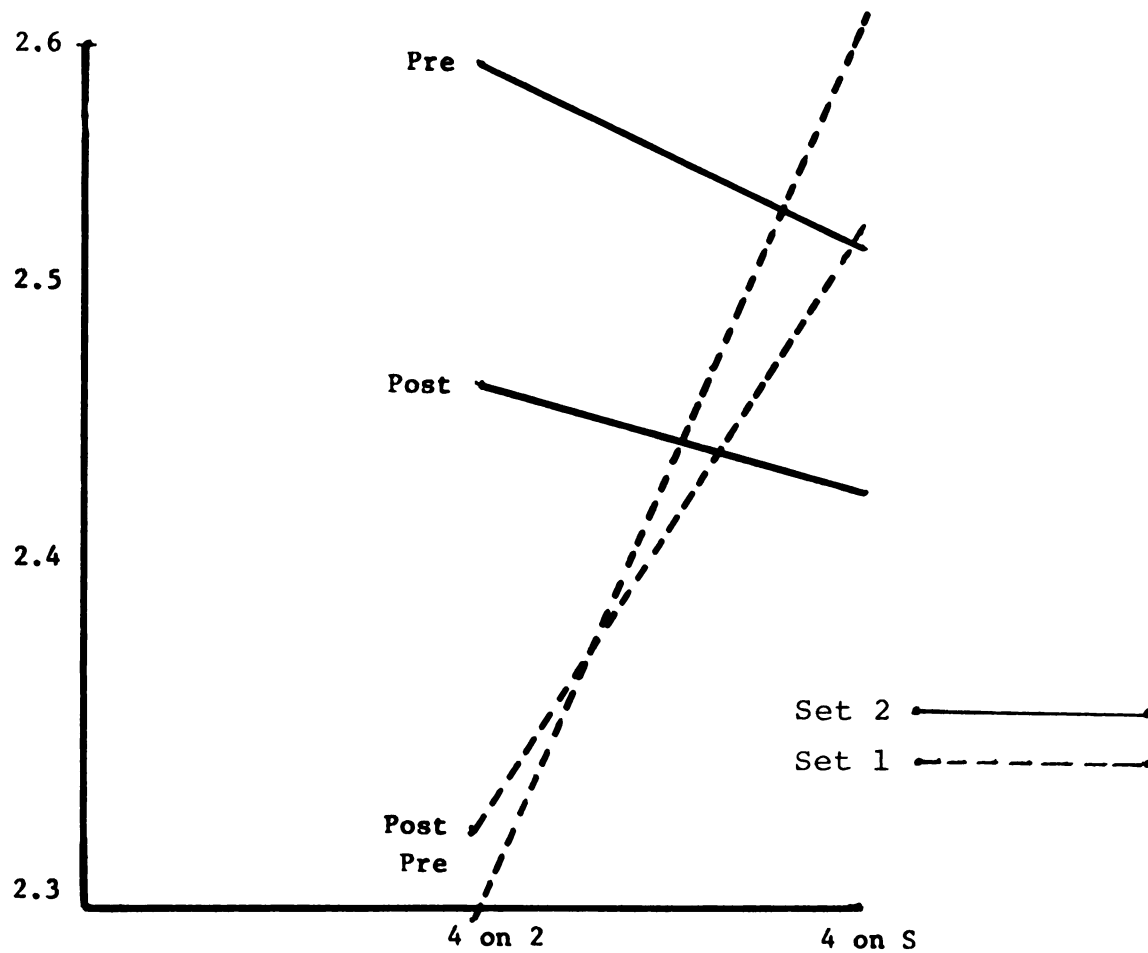


Figure 4. Mean accuracy scores for fourth reproduction, Pattern Sets 1 and 2, under pre- and post-stimulus instructions, using the second reproductions and the original patterns as scoring standards.

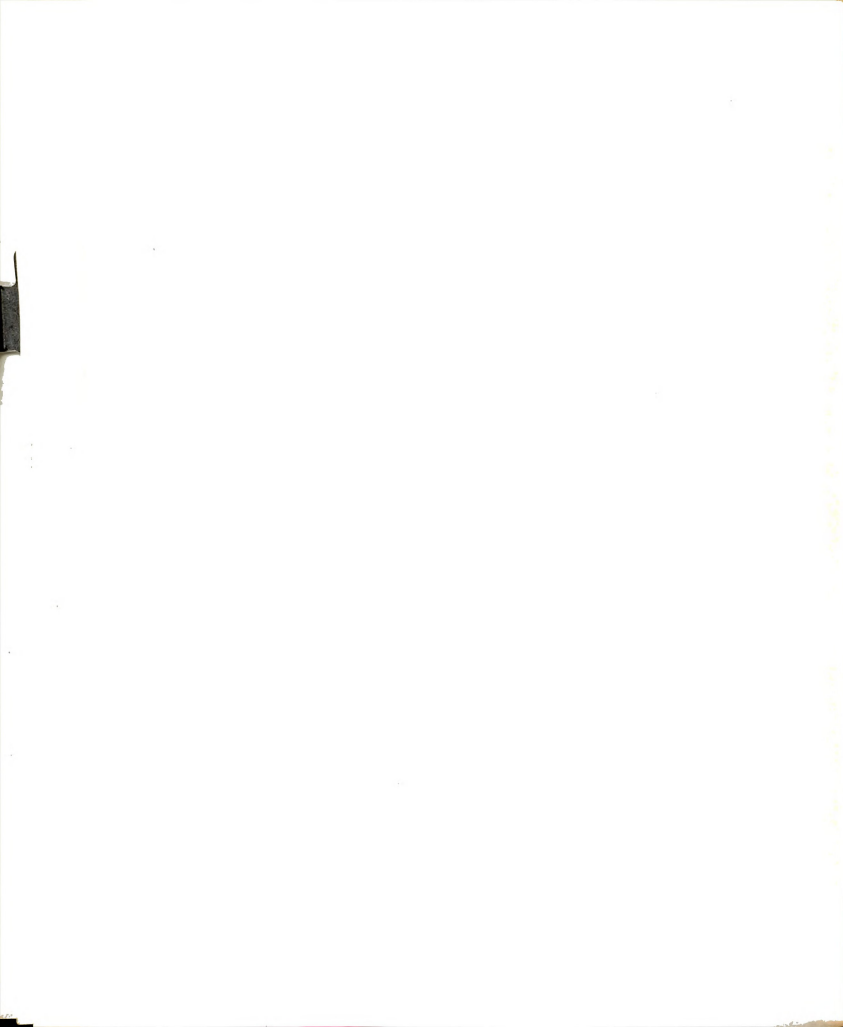


TABLE 4

Mean Accuracy Score for 4th Reproduction, Pattern
Sets 1 and 2 under Pre- and Post-Stimulus
Instruction, Using the 2nd Reproduction
(2) and the Original Pattern (0) as
Scoring Standards

	Scoring Standard		
Pre	2	2.294	2.596
	0	2.617	2.532
Post	2	2.319	2.480
	0	2.534	2.443
		Set 2	Set 1

TABLE 4S

Analysis of Variance

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Total	19.23524	185		
Between (LS)	7.89776	92		
A	0.19881	1	0.19881	2.39289
B	0.23672	1	0.23672	2.84919-*
AB	0.06187	1	0.06187	0.74471
Error B	.39449	89	0.08308	
Within (LS)	6.55013	93		
E	0.55603	1	0.55603	10.26394**
AE	0.01945	1	0.01945	0.35906
BE	1.18550	1	1.18440	21.86112***
ABE	0.05450	1	0.05450	1.00591
Error W	4.82187	89	0.05418	
Factor A: Instructions (Pre/Post)				
Factor B: Pattern Set (1&2)				
Factor E: Score on trial 4 with 2nd reproduction, original pattern, as scoring standard (repeated measure)				

-*.10

*<.05

**<.01

***<.001

along with the original pattern are presented below to clarify the what and why of this scoring procedure. (See Figure 5.)

Retention

Analysis of the 24-hour reproductions presented some statistical problems. Each pattern differed in probability of recall, and thus the possibility existed that probability of recall as a factor might confound the interpretation of differences between the accuracy and total scores of different patterns. For example, it seemed possible that probability of recall might be related to some aspect of performance during acquisition, and that this relationship might be different for different patterns. To check on the feasibility of combining the patterns into pattern sets 1 and 2, as was done in the above analyses, a preliminary analysis of variance was done to look at the factor of probability of recall. That is, the fourth reproduction of all Ss was either classed as DID RECALL (D) or DID NOT RECALL (DN), in a 2x2x2 analysis. Instructions (pre and post), Probability of recall (D and DN), and learning (scores of the second and fourth reproductions on the standard) were the factors. The analysis was done with accuracy scores, on each pattern individually. Briefly, there were no significant main effects, but two significant interactions at the .05 level, from the analysis. The interactions were not in similar directions, which suggests

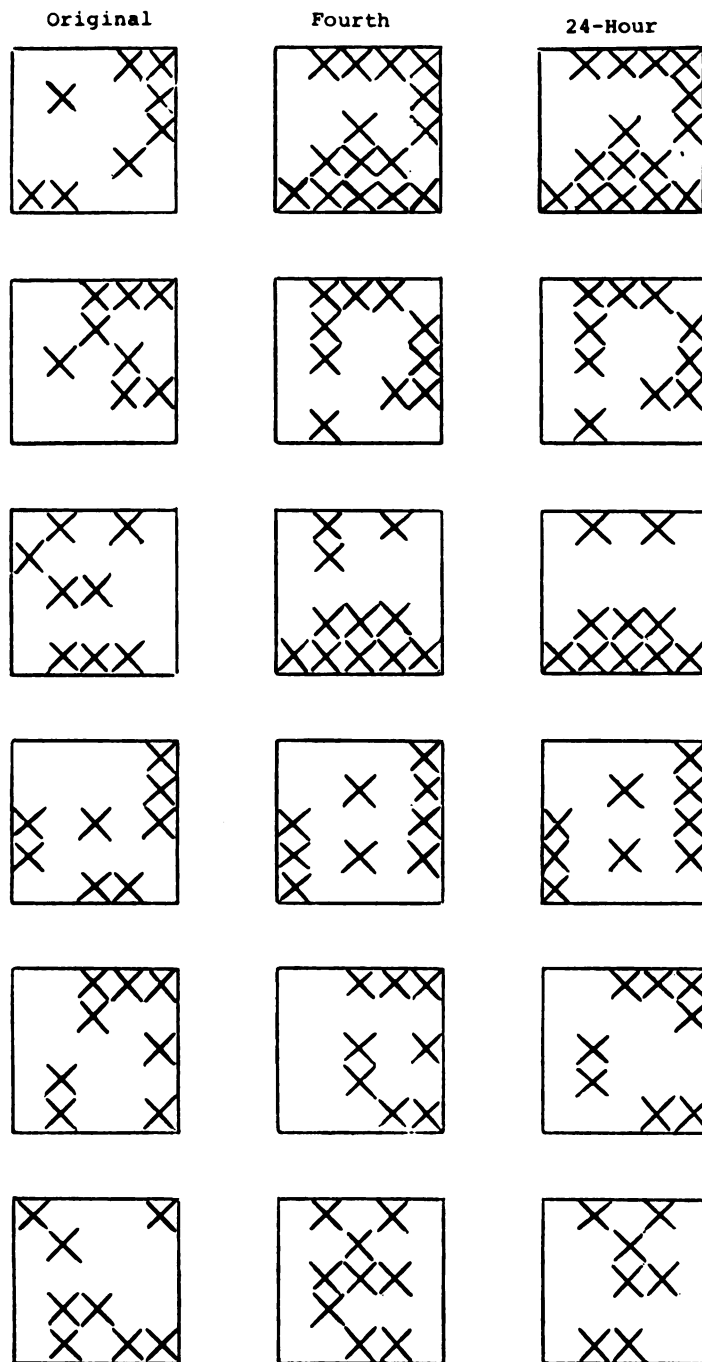
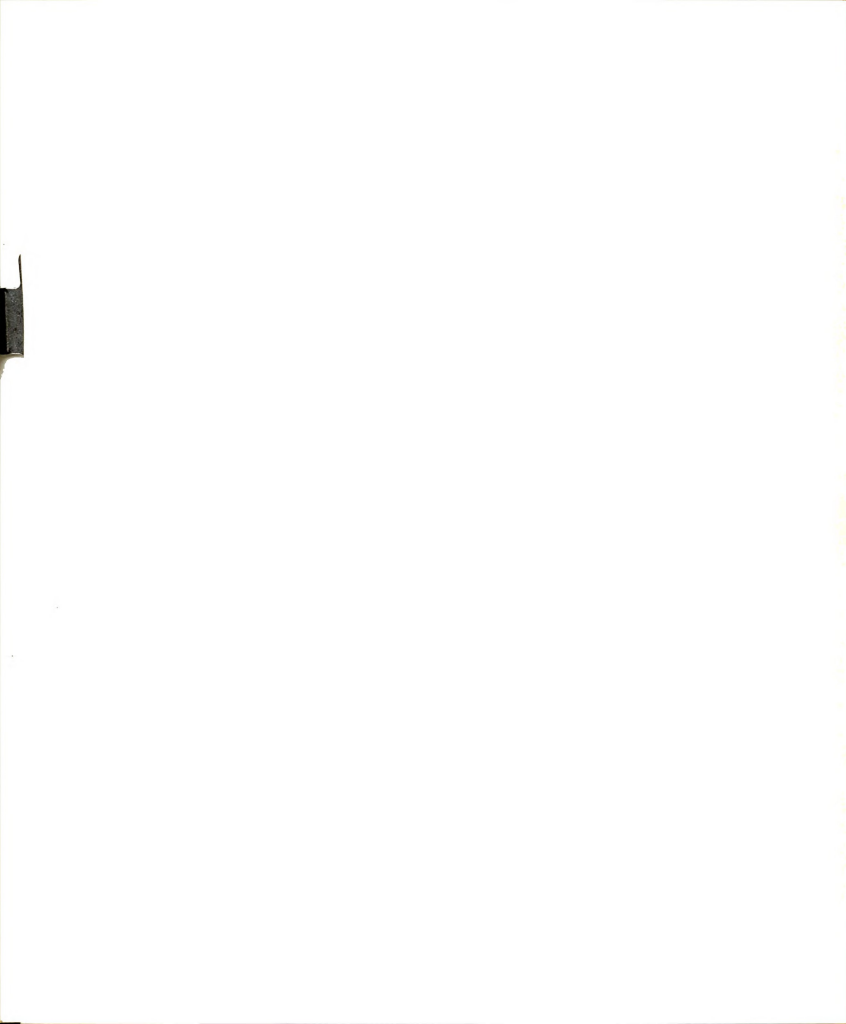


Figure 5. Examples of pattern reproductions which demonstrate perseverative encoding errors, i.e., the S reproduces the pattern with identical or similar errors to an earlier reproduction. Thus, the 24-hour reproduction is more similar to the fourth reproduction than to the original standard. The first row shows the original patterns; the second row shows a fourth trial reproduction for a particular subject for that pattern. The third row shows a 24-hour reproduction of the pattern by the same subject.

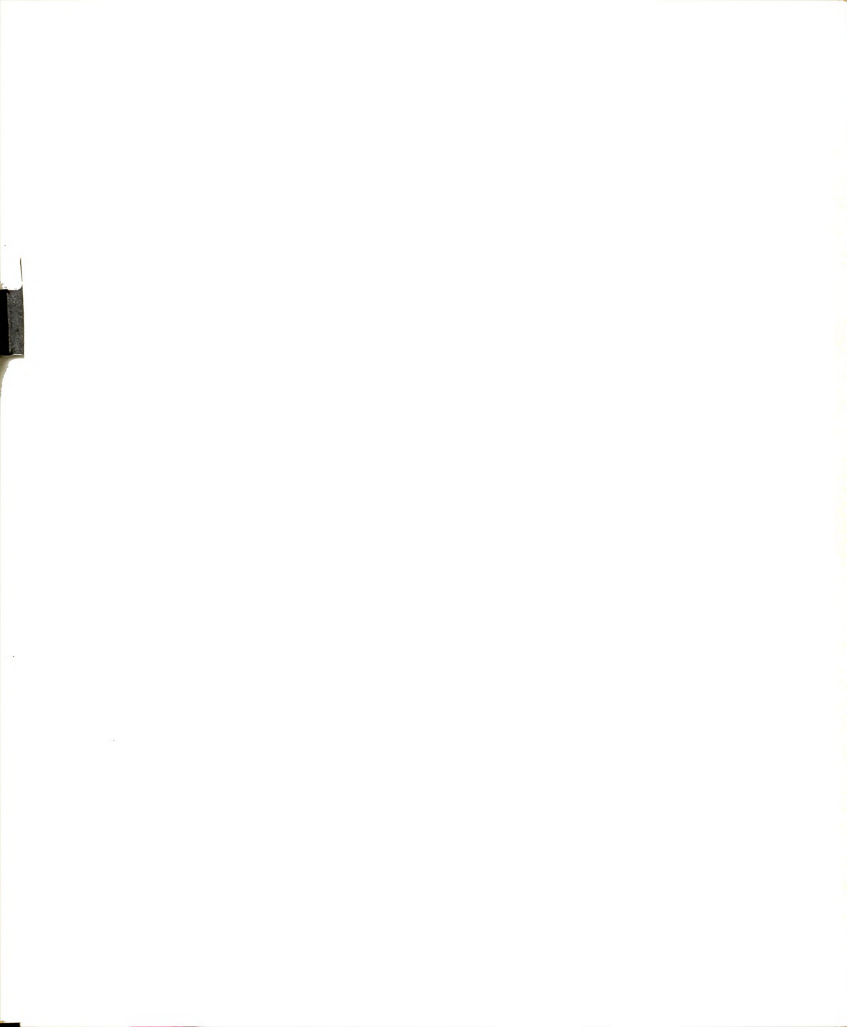


that, if they represent anything more than chance variation, the effects are peculiar to the two individual patterns.

(The interested reader is referred to Appendix C for detailed information on these analyses.) Unfortunately, the two patterns which showed the interactions were both in pattern set 1, i.e., probability of recall as a factor was related to performance in acquisition for two patterns in set 1. Therefore, the combining of patterns into pattern sets for a combined analysis did not seem justified. Instead, the analysis of the accuracy scores of 24-hour reproductions was done for individual patterns. This analysis was clearly weaker than a combined analysis would have been.

Storage

Analysis of the accuracy of the 24-hour reproductions is a way of looking at storage variables. The scoring procedure was not, however, well suited for getting at differences in storage mechanisms. (The original intent of the study was to use two scores for each pattern: a form score, which would reflect form content and placement; and an information score, which would reflect proximity of information, without reference to form. The second of these is clearly inferior as an indicator of a storage scheme, but, for practical reasons we were forced to eliminate the form score.)



To provide a guide for the reader, the following few paragraphs attempt to relate the critical findings of the several analyses before presenting the details of the individual analyses. In attempting to obtain an overview on the relationship between changes in accuracy of reproductions during acquisition and 24-hour retention, two sets of graphs were drawn, and several analyses of variance were computed to evaluate the differences shown in the graphs. In the first set of figures, accuracy scores were plotted for each pattern from reproductions on the second and fourth trials, and from reproductions on the 24-hour test. In the first set of graphs the original pattern was used as the scoring standard (see Figure 6). The first set represented a straightforward relationship between learning and retention. The second set of graphs represented an attempt to examine the relationship between perceptual bias and learning, i.e., will Ss remember a distorted version or an accurate version of the patterns? A perceptual bias is indicated if the Ss recall, at test, a pattern which is closer to an earlier reproduction than to the original pattern. In the second set of graphs, accuracy scores were plotted for each pattern on the second reproduction, using the original pattern as scoring standard, the fourth reproduction using the second as scoring standard, and the 24-hour reproduction, using the fourth reproduction as scoring standard (i.e., 2 on 0, 4 on 2, 24-hour on 4; see Figure 7).

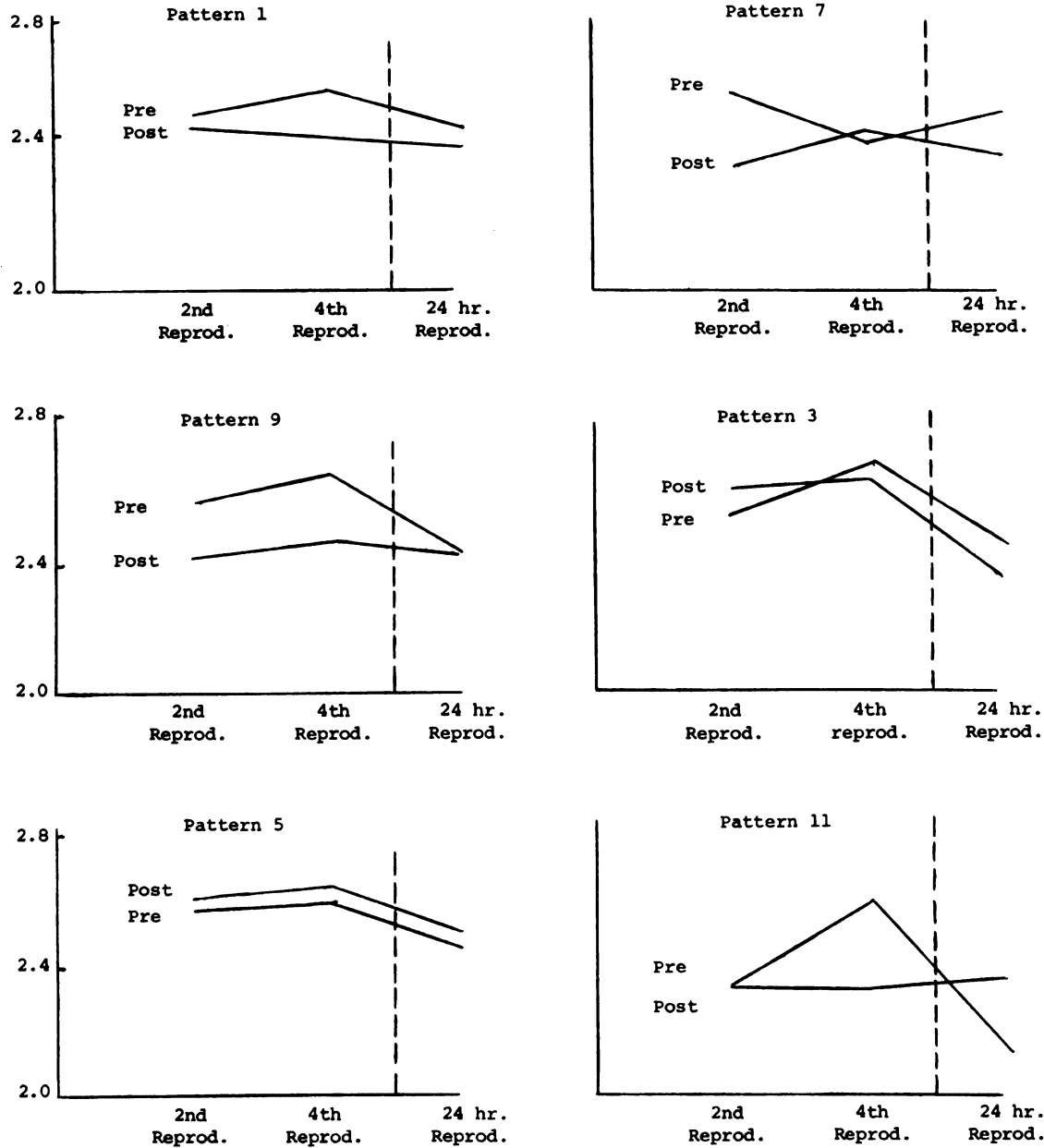


Figure 6. Learning and Retention Profiles: Mean accuracy scores for second reproductions, fourth reproductions, and 24-hour reproductions, under pre/post-stimulus instructions, using the original pattern as the scoring standard.

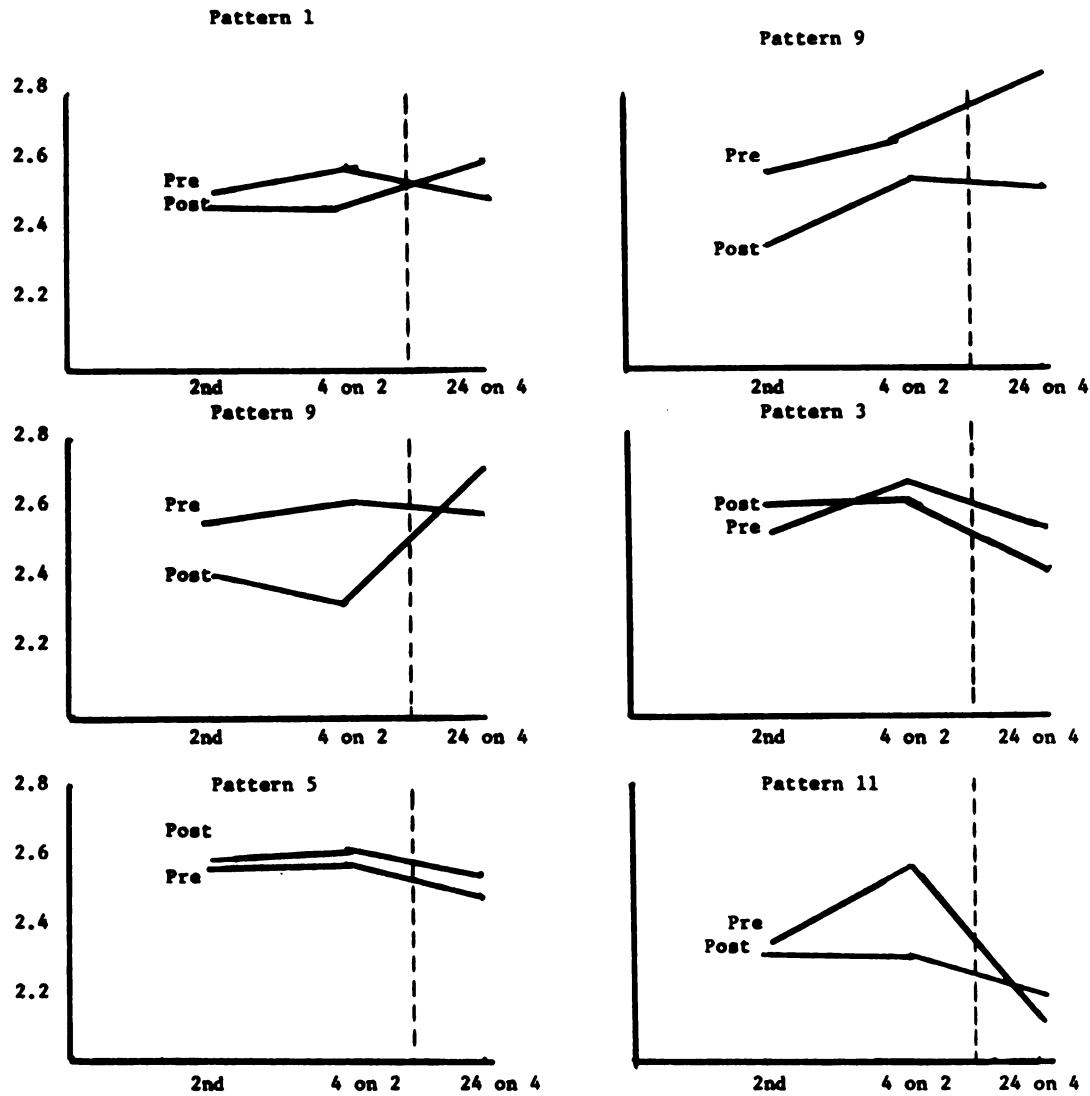


Figure 7. Perceptual Bias Profiles: Mean accuracy scores for second reproductions using the original pattern as scoring standard, fourth reproductions using the second reproduction as scoring standard, and 24-hour reproductions using the fourth reproduction as scoring standard, under Pre- and Post-Stimulus Instructions, for each pattern.

These figures, considered with the data presented above on pattern set differences, revealed a set of consistent relationships between change in accuracy scores across trials and retention. It was mentioned above that there was more improvement across trials for set 2 patterns than for set 1 patterns. It was also pointed out earlier for set 2 patterns that the fourth reproduction scored by the original pattern was better than when scored by the second reproduction, i.e., more learning, less perceptual bias; but the reverse was true for set 1 patterns (i.e., less learning, more perceptual bias). This was a highly significant interaction. Finally, set 1 patterns were recalled and recognized more frequently than set 2 patterns (see Figure 2; Table 1).

A comprehensive overview of the obtained empirical relationships can be described. This overview attempts to relate the results in the above paragraph by concentrating on pattern set differences. Patterns in set 1, which are recalled and recognized more frequently than those in set 2, also receive higher scores on perceptual bias than on learning. This is true for both a short-term memory task and a 24-hour retention test, although the effect on the 24-hour test is greater. Patterns in set 2, which are recalled and recognized less frequently, receive significantly higher scores on learning than on perceptual bias in the short term memory task, but the difference does not

hold on tests of long term retention. Also, set 2 patterns show significantly more change both in learning and retention than set 1 patterns. (Those differences reflect change from trial 2 to trial 4 [learning increases] and from trial 4 to the 24-hour retention test [retention decrease]).

The specific analyses and data which were just summarized are discussed below. Since the relationships described are not obvious, at least at first glance, a summary was presented first to provide the reader with a perspective from which to evaluate the rather cumbersome set of analyses which follows.

Perceptual Bias--Retention Profiles

On the 24-hour reproduction, scored with the fourth reproduction (24 on 4) and the original pattern (24 on 0) as scoring standards. The predictions made concerning the 24-hour reproductions involved a comparison of scores using the original pattern as a standard with scores using the fourth reproduction of that pattern as a standard. A 2x2 analysis of variance was computed with repeated measures on the last factor. The factors were instructions (pre-post) and scoring standard (i.e., the score for the pattern using the original as compared with the fourth reproduction as a scoring standard). A separate analysis of variance

was conducted for accuracy scores on each of the six patterns (see Table 5, 5S).

The scoring standard factor yielded only one significant difference (pattern 9). Examination of the remaining five patterns, four were more accurate when scored by the fourth reproduction as standard than by the original pattern. It should be pointed out that the only pattern which varied was pattern 11. Pattern 11 was consistently different from other patterns on several measures, which suggests that the pattern effects for this pattern were more powerful than the independent variables. Thus, the 24-hour reproductions are, in general, more like their fourth reproductions than the original patterns, especially for patterns in set 1 (see Table 6).

For instructions only one of the six analyses showed a significant effect, while the other five patterns showed no systematic variation. Thus, there is no consistent difference between pre- and post-stimulus patterns on 24-hour reproductions.

Learning-Retention Profiles: Second Reproduction, Fourth Reproduction and 24-hour Reproduction, All Scored with the Original Patterns as Scoring Standards

A 2x3 AOV was done to examine the relationship between accuracy during acquisition and accuracy during recall. For example, large improvement during acquisition might result in higher or lower scores on retention. In

TABLE 5

Accuracy Scores on 24-Hour Reproductions for Each Pattern, for Pre- and Post-Stimulus Instructions, Using the Original Pattern and the 4th Reproduction as Scoring Standards

		Pattern Number		
		1	2	3
Pre	0=2.459 4=2.510	$\bar{X}=2.485$	tr 0=2.446 4=2.547	tr 0=2.448 4=2.487 $\bar{X}=2.467$
Post	0=2.439 4=2.602	$\bar{X}=2.521$	0=2.323 4=2.423	0=2.487 4=2.558 $\bar{X}=2.523$
		9	7	11
Pre	tr 0=2.462 4=2.597	$\bar{X}=2.511$	0=2.512 4=2.832	tr 0=2.164 4=2.152 $\bar{X}=2.158$
Post	0=2.428 4=2.739	$\bar{X}=2.584$	0=2.395 4=2.535	0=2.334 4=2.206 $\bar{X}=2.270$

Note: 0=Original Pattern as Standard; 4=4th Reproduction as Standard.

TABLE 5S

Analysis of Variance
(A Separate Analysis was Done for Each Pattern)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 1				
Total	15.58392	83		
Between (LS)	5.20431	41		
A	0.02704	1	0.02704	0.20895
Error B	5.17727	40	0.12943	
Within (LS)	4.88523	42		
E	0.23372	1	0.23372	2.04997
AE	0.06460	1	0.06460	0.056659
Error W	4.56056	40	0.11401	
Pattern 7				
Total	10.97627	41		
Between (LS)	7.15300	20		
A	0.44744	1	0.44744	1.26780
Error B	6.70557	19	0.35292	
Within (LS)	4.25557	21		
E	0.55441	1	0.55441	2.89737
AE	0.08477	1	0.08477	0.44302
Error W	3.63563	19	0.19135	
Pattern 9				
Total	23.24525	57		
Between (LS)	5.50094	28		
A	0.07338	1	0.07338	0.36504
Error B	5.42756	27	0.20102	
Within (LS)	4.71433	29		
E	0.81445	1	0.81445	5.91238*
AE	0.06914	1	0.06914	0.50192
Error W	3.71984	27	0.13775	
Pattern 3				
Total	9.17868	57		
Between (LS)	5.48825	28		
A	0.22144	1	0.22144	1.13520
Error B	5.26681	27	0.19507	
Within (LS)	2.67934	29		
E	0.14632	1	0.14632	1.55978
AE	0.00000	1	0.00000	0.00000
Error W	2.53284	27	0.09381	

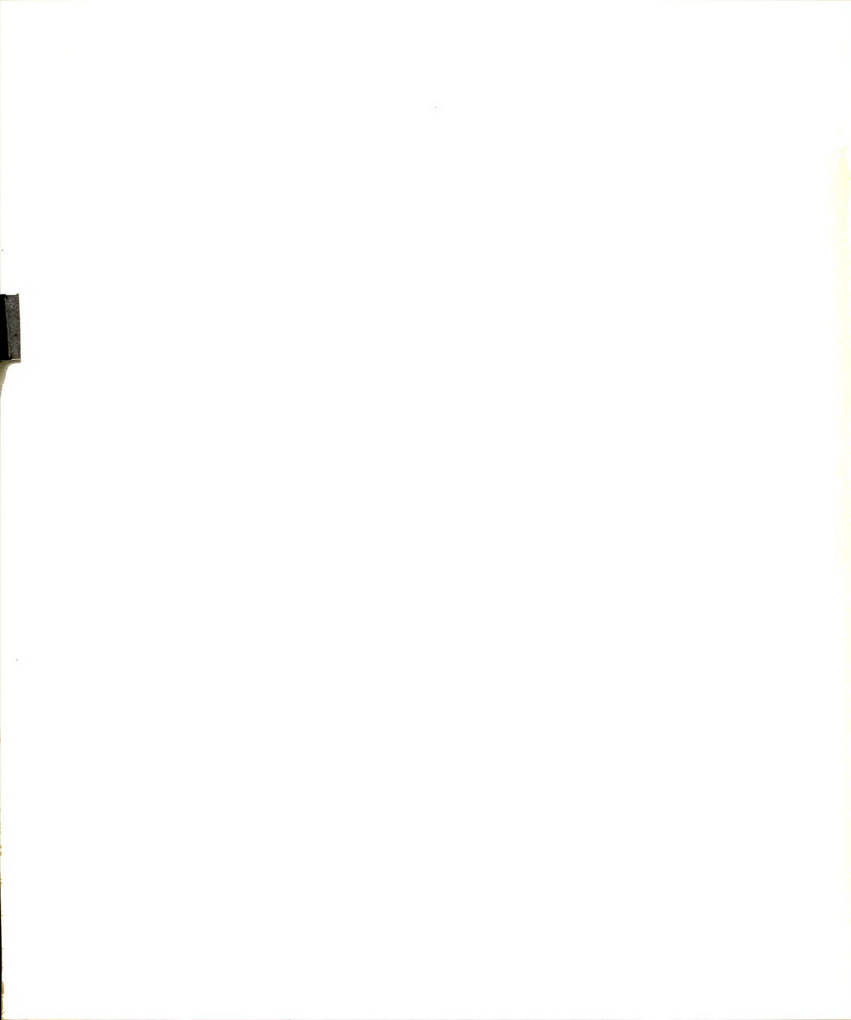


TABLE 5S (Continued)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 5				
Total	8.32740	57		
Between (LS)	2.18579	28		
A	0.04422	1	0.04422	0.55746
Error B	2.14157	27	0.07932	
Within (LS)	1.44624	29		
E	0.04390	1	0.04390	0.84925
AE	0.00364	1	0.00364	0.07045
Error W	1.39554	27	0.05169	
Pattern 11				
Total	39.10218	41		
Between (LS)	3.16208	20		
A	0.10746	1	0.10746	0.66838
Error B	3.05462	19	0.16077	
Within (LS)	2.55827	21		
E	0.04144	1	0.04144	0.31383
AE	0.02798	1	0.02798	0.21188
Error W	2.50898	19	0.13205	

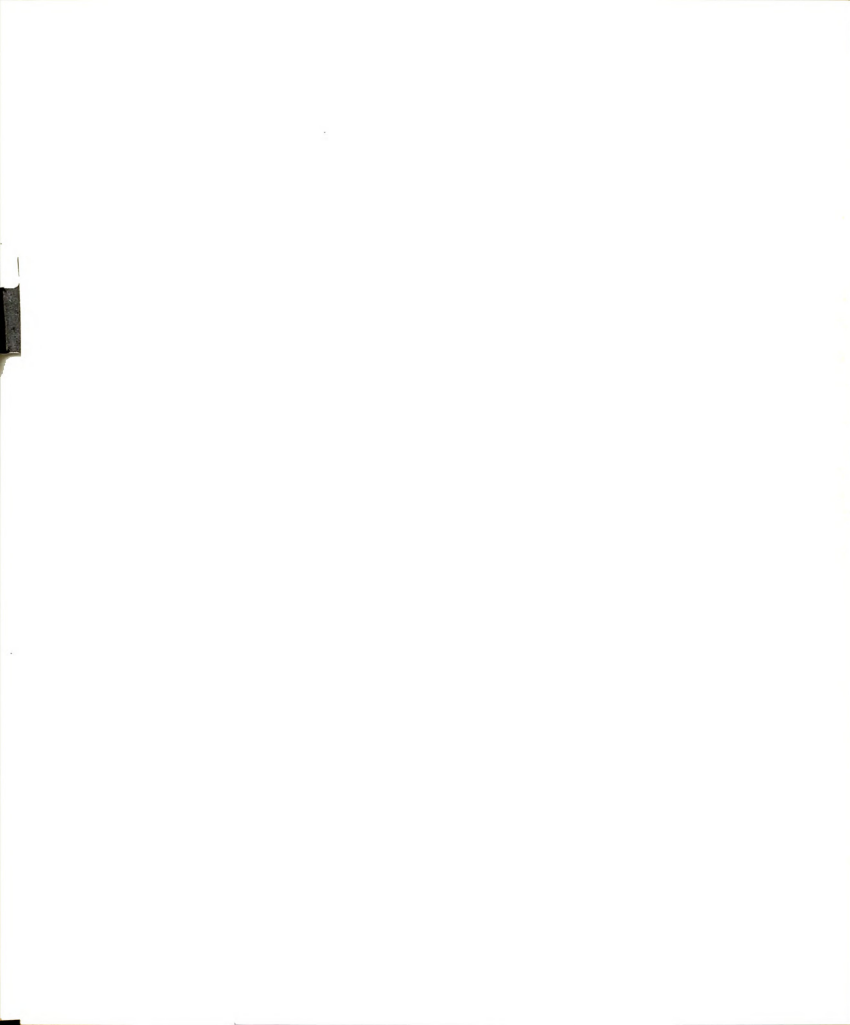


TABLE 6

A Comparison of Mean Accuracy Scores for Each Pattern
on the 24-hr. Test, Scored with the Original
Pattern (0) and 4th Reproduction (4)
as Standards

	Pattern Number					
	1	7	9	3	5	11
0	2.464	2.453	2.427	2.377	2.465	2.248
4	2.555	2.683	2.668	2.485	2.523	2.179

the analysis, Instructions (pre-post) and changes during learning and retention (i.e., the change from trial 2 to trial 4 to the 24-hour reproduction) were the factors. The analysis was performed on accuracy scores for each of the six patterns. The graphical representation of these changes, and their respective statistical analyses can be seen in Figure 6 and Tables 7 and 7S.

For Instructions, only one analysis (Pattern 11) showed a significant effect. The instructions x learning-retention change interaction was also significant ($F=9.682$, $p < .05$) for pattern 11. The remainder of the differences were not consistently in one direction, so it is likely that the instructions effects here, as in the above analyses, are either chance occurrences due to the large number of tests run, or they are reflections of powerful pattern-by-instructions interactions which are different for different patterns. (Since different scanning techniques will be more or less successful depending upon the distribution of the pattern in the field, this suggestion does not seem unreasonable.)

For the learning-retention factor, none of the patterns of set 1 (1, 7, 9) showed significant changes, in accuracy scores, while for pattern set 2 (3, 5, 11) all three patterns showed significant changes across trials. If statistical assumptions had allowed combining the patterns into sets as for the earlier analyses it is likely

TABLE 7
Accuracy Score for 2nd and 4th Reproduction, and
24-Hr. Reproduction Under Pre/Post
Instructions, Using the Original
Pattern as the Scoring
Standard

		Pattern Number					
		Trial	1	7	9	3	5
Pre- instruction	2		2.5176	2.5800	2.5650	2.540	5.271
	4		2.5951	2.4392	2.6440	2.687	2.589
	24		2.4897	2.5118	2.4620	2.446	2.448
Post- instruction	2		2.4937	2.3773	2.414	2.607	2.593
	4		2.4643	2.4583	2.451	2.627	2.623
	24		2.4399	2.3951	2.428	2.308	2.482

2.346
2.581
2.164

2.314
2.302
2.334

TABLE 7S

Analysis of Variance
(A Separate Analysis was Done for each Pattern)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 1				
Total	17.83954	122		
Between (LS)	6.18444	40		
A	0.14086	1	0.14086	0.90901
Error B	6.04357	39	0.15496	
Within (LS)	2.77681	82		
E	0.08688	2	0.04344	1.28535
AE	0.06285	2	0.03143	0.92986
Error W	2.63610	78	0.03380	
Pattern 7				
Total	5.75650	62		
Between (LS)	3.15874	20		
A	0.16281	1	0.16281	1.03254
Error B	2.99593	19	0.15768	
Within (LS)	2.48429	82		
E	0.00899	2	0.00450	0.07298
AE	0.13547	2	0.06823	1.10738
Error W	2.34147	38	0.06162	
Pattern 9				
Total	18.95150	86		
Between (LS)	3.70877	28		
A	0.27399	1	0.27399	2.15378
Error B	3.43479	27	0.12721	
Within (LS)	3.47582	58		
E	0.20516	2	0.10258	1.74695
AE	0.14821	2	0.07410	1.26200
Error W	3.17086	54	0.05872	
Pattern 3				
Total	10.31926	83		
Between (LS)	3.36272	27		
A	0.03963	1	0.03963	0.31009
Error B	3.32309	26	0.12781	
Within (LS)	3.52765	56		
E	1.15282	2	0.57641	13.29389***
AE	0.14748	2	0.07374	1.70063
Error W	2.25466	52	0.94336	

TABLE 7S (Continued)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 5				
Total	6.80137	83		
Between (LS)	1.45906	27		
A	0.01838	1	0.01838	0.33174
Error B	1.44968	26	0.05541	
Within (LS)	2.09916	56		
E	0.31898	2	0.15949	4.66234*
AE	0.00070	2	0.00035	0.01029
Error W	1.77882	52	0.03421	
Pattern 11				
Total	71.06104	62		
Between (LS)	1.32309	20		
A	0.02866	1	0.02866	0.42064
Error B	1.29443	19	0.05813	
Within (LS)	3.38234	42		
E	0.32151	2	0.16975	2.95247-*
AE	0.43153	2	0.21576	3.96282*
Error W	2.96900	38	0.05445	
Factor A: Instructions (Pre/Post)				
Factor E: Scores for 2nd, 4th, and 24-hour reproductions (a repeated measure)				

-* <.10

* <.05

** <.01

*** <.001

that a pattern set x learning-retention changes interaction would have been significant. Since Pattern Set 2 is the more difficult in terms of both recognition and recall, it looks as if the accuracy score is more likely to change across trials for difficult than for easy patterns.

A second set of graphs was plotted to examine the effects of previous reproductions on processing and retention. Specifically, accuracy scores from the second trial reproduction scored by the standard, the fourth trial reproduction scored by the second trial reproduction, and the 24-hour reproduction scored by the fourth reproduction as standard, were plotted to compare with the graphs of Figure 6. (See Figure 7.) This is an analysis of retention as a function of differences in performance on the first day, focusing on different aspects of performance. Specifically, the tendency to improve a reproduction measured against an external standard is compared with the tendency to consistently reproduce a similar version of an earlier reproduction. The effects of these conflicting tendencies on 24-hour retention is assessed by comparing 24-hour retention of patterns which showed considerable improvement in accuracy in Day 1, but less consistency.

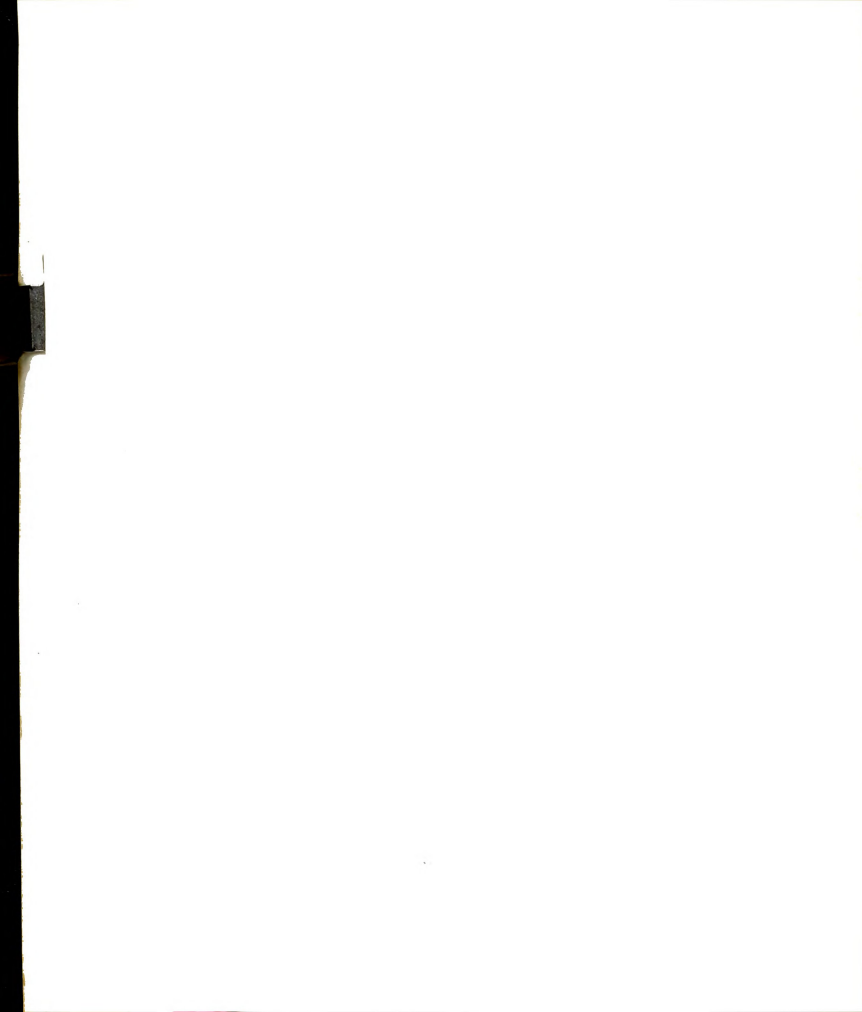
The profiles in Figure 7 versus Figure 6 differed only for patterns in set 1. For those patterns, two of the three pre-stimulus groups, and all of the post-stimulus groups showed a substantial increase in accuracy on the

24-hour test when scored by the fourth reproduction. This was shown in Table 6 above, but the profiles show that the effect is much more pronounced for patterns in set 1 than those in set 2.

Summary

A reiteration of the most important findings may help point out the consistency of relationships in the above analyses. The demand condition (Recall or Recognition) yielded highly significant effects for the frequency data (mean number recalled and recognized). The instructions effect differed for the two demand conditions as did the test condition effect: For patterns acquired with a recognition demand the main effect for instructions was highly significant (with post-stimulus instruction better than pre-); similarly, the main effect for test condition under a recognition demand was highly significant (with a recognition test giving much higher scores than a recall test). For patterns acquired with a recall demand neither instructions nor test conditions produced significant main effects.⁴ A significant pattern set x tests condition interaction and a significant pattern set x instructions x test condition interaction were found. The main effect of pattern sets was also significant, with

⁴This is, of course, the most critical finding in the study.



pattern set 1 always recalled and recognized more than pattern set 2.

The analysis of changes during acquisition and 24-hour retention are best summarized by describing the profiles. Substantial learning (i.e., large changes in accuracy from trial 2 to trial 4 as found for set 2 patterns) were accompanied by a substantial drop in performance in the retention test. Less learning (smaller changes in accuracy from trial 2 to trial 4 as found for set 1 patterns) is accompanied by a smaller loss in recall at 24 hours and greater perceptual bias, i.e., a substantial increase in accuracy score for the fourth reproduction if an earlier reproduction is the scoring standard. Thus, smaller changes in accuracy during acquisition indicate that the pattern is reproduced consistently, and an earlier reproduction is a better predictor of a latter reproduction than is an actual standard. This increase is magnified on the 24-hour test with patterns with smaller accuracy changes on day 1 showing large increases if scored on the fourth reproduction rather than the standard. This indicates that storage is effected by perceptual bias during acquisition.

The predictions of the experiment can be assessed as follows: (a) The predicted advantage of pre-versus post-instructions for the accuracy of 5-second reproductions was not confirmed. However, the pre-stimulus instructions did produce more improvement in accuracy

across trials than the post-stimulus instructions, as shown in the Instructions x Trials interaction. (b) There were no significant accuracy score differences between patterns under the pre- and post-instructions, 24-hour test, with the fourth reproduction used as scoring standard. This supports the original prediction that there would be no significant difference, but the results are not as meaningful as they would have been if prediction (a) had been supported. (The gist of prediction (b), on the other hand, was clearly confirmed in pattern set differences when 24-hour reproductions were scored by the fourth reproductions.) (c) The prediction that the 24-hour reproduction would be closely related to the fourth reproduction could not be evaluated. The expected differences were based upon the differences expected as a function of Instructions on the first day. Since there were none, the projected effects (pre better than post) were not found. (d) The most critical prediction, that frequency of recall at test with a recall demand during acquisition would not be significantly different from frequency of recognition with a recall demand, and that frequency of recall at test would be significantly less than frequency of recognition at test under a recognition demand during acquisition was unequivocally supported. (e) This prediction referred to form and information score differences, but could not be evaluated because, as was mentioned above, form scores were dropped from the analysis.

DISCUSSION

In the present paper, it was postulated that the amount of information and kinds of information needed for success in a test of immediate recognition are different from those needed for a test of immediate recall. In addition, it was postulated that different styles of selecting information would be adopted as a result of the demands of the two tasks. From these postulates, it was predicted that the difference between recognition and recall measures of retention would reflect the conditions of acquisition. That is, retrieval of information on a test would be poor if retrieval had not been required during acquisition. The model presented in the introduction suggested that recognition demands require only encoding processes, while recall demands require both encoding and decoding. The model, as well as the more detailed set of assumptions underlying it (Appendix A) received considerable support. Some details of the results provided guidelines for formulating a more detailed model to be presented later in this section.

Frequency of Recall--A Function of Retrieval Differences

In Postulate III in Appendix A, it was stated that central retrieval processes are independent of perceptual integration (encoding). The perceptual or encoding process determines what gets into the system, while the retrieval process determines what is available for recall. Evaluation of retrieval differences was the primary purpose of the present study. It was predicted that differences in frequency of recall would be a function of the acquisition condition. The data on frequency of recall and recognition data supported the prediction that, when materials are acquired under a recall demand which, it is assumed, culminates in central retrieval of the information, the differences between the two (recall and recognition) measures at test will disappear. Thus in the present study, if central retrieval was never required during acquisition (i.e., for patterns acquired with a recognition procedure) the retention differences between the recall and recognition measures were highly significant. But the difference between the two measures for retention of the same information under the same testing conditions disappeared when recall was required during acquisition (i.e., for patterns acquired with a recall procedure). The simplest interpretation of these results is that the processing elicited by recall and recognition tasks is fundamentally different. These data provide

strong support for the dual process theory first suggested by Muller (1913), which states that the retrieval stage of memory is independent of the recognition stage. It extends the findings of Estes and DaPolito (1967) to unfamiliar and non-verbal materials. The implications of the present findings are that the independence of retrieval from recognition of information is not restricted to the special case of retention of verbal materials.

Frequency of Recognition: A Function of
Motivation and Signal Strength

According to the model in the introduction, recognition involves only encoding of information. Therefore how much information was encoded, and how accurately the information was encoded, are the critical determinants of recognition performance at test. The argument is made below that a recall demand will elicit more encoding than a recognition demand. In addition, it is argued that the greater amount of available information under pre- as compared with post-stimulus instructions should affect the accuracy of the encoding response.

In attempting to describe the way in which these two variables affect processing the following assumption was made: S will choose the processing method which requires the least energy to accomplish the task. This will vary for individuals, but as a normative assumption, it seems reasonable. On the immediate memory test, the

recognition task was always described by Ss as easy, while the recall task was always described as difficult. Also, there were almost no recognition errors on the short-term memory task. From this, it may be deduced that recognition as compared with recall required less processing of information, i.e., less encoding, for accurate performance during acquisition. In terms of the availability of information, it is obvious that less information is available after five seconds than immediately following stimulus termination. Another consideration is that the uncertainty of the demands of a post-stimulus as opposed to pre-stimulus instruction will increase the random encoding which occurs prior to instructions. Thus, X amount of information will be randomly encoded prior to instructions, and the amount of information remaining to be encoded when instructions are given is small. That is, both random encoding and decay in the visual system would reduce the information available for encoding five seconds after stimulus termination. Combining these considerations, we can make the following simple prediction: (1) Less information will be encoded under a recognition demand than a recall demand. (2) This negative effect on amount encoded will be greater for pre- than post-stimulus instructions.

These two relationships, which summarize the major results for the data on recognition frequency, can be translated into a general formula:

$$X + R(A)/X + R \quad F(A)/F \quad \text{while} \quad X + R(B)/X + R \sim F(B)/F$$

where A = the limit or reduction in encoded information resulting from the motivational effect of a recognition test, B = the reduction resulting from the motivational effect of a recall test. (Both A and B could be expressed as a constant per cent of the information remaining after five seconds, i.e., R/F = the full amount of information in the pattern). These formulae describe relationships rather than quantities. It should be possible to empirically determine the constants in the formula for particular information under specific temporal relationships. These relationships described by the formula with variables should be accurate for all types of information.

The formulas represent the two assumptions that (1) a recognition task requires less encoding than a recall task, and (2) there is more information to be encoded when the task demand is presented as a pre-stimulus rather than a post-stimulus instruction. The one exception to the latter relationship which was found, the set 1-recall condition, can be interpreted as an indication that set 1 patterns are easily encodable, so that the randomly encoded information (X) would not differ significantly from the information systematically encoded under a recall demand; hence, no significant difference was found between the pre- and post-stimulus instruction conditions for the recognition measure. While the postulates of Model I are

consistent with the data on 24-hour recognition and recall performance, a more detailed treatment is necessary to incorporate the effects of pattern difficulty and signal strength. Before getting to these more complicated theoretical considerations, we should consider the implications of the finding already discussed, particularly the elimination of differences between recognition and recall at test with a recall acquisition procedure.

These results are particularly difficult for a theory of memory which assumes (a) that there is only one memory process, with short- and long-term memory explained by a single process (e.g., Melton, 1961, 1963), and (b) that recognition and recall differences are a reflection of the strength of a memory trace, or of the strength of single S-R connections. It is difficult to imagine how memory strength, viewed as a single dimension, could account for the large differences in recall that were obtained as a function of the two acquisition procedures. Since Ss were required to trace the correct pattern under a recognition demand after selecting it from alternatives, both time and interaction with the material was equated. The present analysis suggests that the only difference was the source of information being retrieved during acquisition, i.e., central retrieval was required for the recall task, while peripheral information was available for the recognition task.

Implications for Educators

It is important to examine the implications of these results, since they differ sharply from those of the Postman et al. study. The implications of the earlier study for educators were that a recognition test was not only a permissible short-cut (referring to the obvious advantages for grading tests more easily and reliably), it was in fact a preferable method, since it provided a more sensitive measure, and increased the memory of its items simultaneously. These implications are seriously challenged by the present research, which suggests, to the contrary, that information acquired passively, in preparation for a test of peripheral retrieval (i.e., a recognition test), will only be useful if later opportunities for recognition of the information occur. Active recall of information acquired in this way is seriously impaired. These data, along with the Estes and DaPolito data (1967), suggest that this point applies to familiar verbal materials, as well as unfamiliar non-verbal materials. Therefore, if one major goal of teaching is to provide the student with usable information, it is not wise to encourage passive learning by giving passive tests. Only a demand to set up active retrieval of information encourages the learning activities required for true assimilation of information. If motivation, as well as assessment, is a major consideration in testing, it is recommended that

whenever possible we should abandon methods of testing which do not require active retrieval of information.

Individual Patterns and Pre-Post Differences:
Effects on Information Selection

Using the estimates of Sperling (1960a) on the duration of useful information in the visual system we assumed that an instruction delayed for 5 seconds would no longer affect stimulus selection, while a pre-stimulus instruction would clearly affect stimulus selection. The validity of this assumption was recently challenged by research reported while the present study was being conducted. This research found that non-encoded visual information may be available for simple decisions as long as 10 seconds (Liss, Reeves, & Wildfogel, 1971). The duration of useful information in the visual system may be related to the difficulty of the task, i.e., simpler decisions can be made from information which fades less quickly.

This notion is not entirely new. Neisser (1970), in reviewing the research on the duration of information in the peripheral auditory system, arrived at a similar conclusion. Pollack (1959) found that providing a small set of alternatives at varying delays after stimulus presentation facilitated accuracy, as a decreasing function which leveled off at 4 seconds. Neisser argued that this represents the point at which "iconic" or peripheral

information was no longer useful. Euleson and Johnson (1964) used a simpler task than Pollack. Two Ss read a novel for two hours. Occasionally a beep was presented, and at varying delays the reading lamp went out; the Ss were then asked whether they had just heard the beep. The estimate of useful information in this task was 10 seconds, much like Liss et al.'s (1971) data for visual information. The Lawrence and Coles (1954) study which used a post-cueing procedure similar to Pollack's did not use varying intervals, so a direct comparison cannot be made. The available data suggest that both visual and auditory information is available for fairly complicated decisions up to 4 seconds, and for simple decisions up to 10 seconds. Finally, research by Kahneman and Norman (1964) indicated that the effective range of the law of reciprocity may be affected by the task involved. Briefly, the reciprocity law states that increases in either the intensity of a visual stimulus (I) or the time of its exposure (t) will cause an increase in E ($Ixt=E$) up to a certain maximum value of t (t_c). The value of T_c (the maximum value of t at which reciprocity applies) is greater for more difficult tasks. More research is needed to evaluate the relationship between these various findings, but it is clear that the useful duration of information is affected by how it is used.

The variable of pre- and post-stimulus instruction, in lieu of this, may be viewed as representing a rather different situation for retrieval than suggested in the introduction. If, for the post-stimulus recall condition, the information being retrieved had been encoded, involving central retrieval, the original conception offered in the Introduction would be reasonable. Such recall instructions could not affect the selection of information from the visual system. That is, since the information would have been encoded prior to the instructions, pre-stimulus instructions but not post-stimulus instructions, will have affected information selection. If, on the other hand, information is being retrieved from the visual system for both pre- and post-stimulus recall, performance under the two temporal placements of the recall instruction will be affected by the decay of the information in the visual system, and whatever effects that decay may have on encoding. This conception is tempered by another consideration: pattern differences. The data suggest that the amount that can be encoded in one trial varies with pattern used. Thus, different patterns differ in the amount of central and peripheral retrieval on a trial, and this will interact with the effects of decay in the visual system.

The construct of encoding will be used in attempting to explain the differences found as a function of pattern difficulty and Instructions. The critical parameters

are the amount of encoding per trial, the consistency of encoding across trials, and the amount of decay in the visual system. It is hypothesized that encoding a smaller portion of information per trial results in greater accuracy and improvement across trials, while encoding a major portion of the pattern on every trial increases the consistency at the cost of decreasing the accuracy of encoding. And, of course, accuracy will decrease as the information in the visual system decays. The specific applications of these hypotheses toward explaining the differences found between pre- and post-stimulus cueing and easy versus difficult patterns, are presented below.

I. Pre-stimulus instructions to recall and partial encoding. Pre-stimulus instructions to recall produce more improvement across trials than post-stimulus instructions to recall. This may be because a smaller portion of the patterns are encoded under a pre-stimulus instruction. The logic behind this explanation is as follows: If a S knows he must reproduce the pattern, he will try to encode it prior to recall. Encoding does not pay off initially because encoding followed by central retrieval takes longer than peripheral retrieval. However, if a pattern has been partially encoded on an earlier trial, S may chunk the information, so that a larger portion of the pattern may be encoded on a later trial (Miller, 1956a; Hebb, 1961).



Thus, a pre-stimulus instruction to recall encourages partial encoding, which results in improvement across trials.

II. Pattern difficulty and partial encoding.

Internal consistency among the results is required if all the implications regarding the partial versus complete encoding hypothesis are to be supported. The variable of pattern difficulty should affect performance similarly to the variable of instructions. The more difficult patterns in Set 2 showed more improvement across trials than patterns in set 1. A pattern which is more difficult to encode will be encoded more slowly, and hence a smaller portion of the pattern will be encoded on one trial (the exposure time is equal for all patterns). By focusing the encoding process on a smaller portion of the pattern, the partial encoding associated with more difficult patterns should produce more accurate encoding, and if the encoded information is "chunked" for later trials, improvement across trials should result, and it did.

III. Encoding errors, retrievability, and complete encoding.

Set 1 patterns were (a) lower in accuracy scores than set 2 patterns if the scoring standard was an original pattern; (b) higher in accuracy scores than set 2 patterns, if the scoring standard was an earlier reproduction; and (c) recalled more frequently than set 2 patterns. Using the interpretation that easy patterns are more likely to be encoded in one trial than difficult patterns, the following

explanation was derived: If a pattern is completely encoded on one trial, it is likely that it will be completely encoded on the next trial. The selective and organizational tendencies will increase in strength with repeated exposures. It is also likely that reproductions based on this encoding will include errors, and these errors will tend to perseverate. An example may aid in explaining this assumption. Let us suppose that a S has the task of recognizing a sequence of numbers from a brief exposure. If the numbers were in a counting sequence, i.e., 1-10- they would be scanned rapidly and would follow a particular encoding scheme. It would be easy for the S to place an item in the last half of the sequence which would be misperceived (e.g., a 3 instead of an 8). That is, if the information does not fit the encoding scheme, it may be distorted, or inaccurately encoded. Finally, since according to the present framework the consistency of decoding (i.e., retrieval of encoded information) determines the availability of information, a pattern encoded completely and consistently across trials will be more available in a recall test than a pattern which was not processed completely and consistently.

IV. Post-stimulus instruction: The interaction of uncertainty and difficulty. An interaction between pattern difficulty and instructions was found, with set 1 patterns recalled more frequently under a post-stimulus instruction,

while set 2 patterns were recalled more frequently under a pre-stimulus instruction. This can be explained by examining the effects of the two variables on encoding per trial. The post-stimulus condition provides the least structure for processing, i.e., since S does not know whether a recall or recognition test will be given, other variables, such as pattern difficulty, can have a greater effect. Easier patterns (set 1) tend to be encoded entirely on one trial prior to retrieval, thus increasing the likelihood of central retrieval. The pre-stimulus instruction encourages partial encoding, going against the tendency to encode the easy patterns completely on one trial. Thus for set 1 patterns, post-stimulus recall produces less accurate, but more consistent encoding than pre-stimulus recall resulting in better retrieval than pre-stimulus recall for easy patterns.

For the difficult (set 2) patterns, the tendency to encode only a part of the pattern on one trial is reinforced by the same tendency to encode partially under a pre-stimulus condition. This maximizes the opportunity for "chunking," producing the most improvement across trials. The post-stimulus condition provides little structure, and after 5 seconds, the information being encoded has nearly faded from the visual system. The slow rate of encoding for difficult patterns, combined with the delay of encoding

due to the post-stimulus instruction, should produce both inaccurate and inconsistent coding.

V. Long-term storage and partial versus complete encoding. No clear prediction can be derived concerning differences in scores of 24-hour reproductions, between patterns encoded completely or in part. The encoding scheme for patterns encoded completely may be quite inaccurate, biasing the selection of certain parts of the pattern. The partial strategy may not provide adequate opportunity for integration of the parts sampled on different trials. The results, in fact, revealed no significant differences in accuracy scores on 24-hour reproductions between set 1 and set 2 patterns. A final bit of supporting evidence is offered here for the partial encoding interpretation of the differences between pattern sets 1 and 2. If patterns in set 2 were encoded in part and hence reproduced in part more often than was true for patterns in set 1, it would be reasonable to predict that this encoding difference would affect the degree of correspondence between recognition performance and recall performance, particularly if the alternatives on the recognition test were highly similar and hence demanded more information for accurate discrimination. This was the case, as 84% of patterns in set 1 which were recalled at 24 hours were also recognized, while only 54% of those not recalled were recognized. In contrast for pattern set 2, only 66% of those recalled

were recognized accurately, compared with 57% of those not recalled. Clearly, recall of patterns in set 1 was a better predictor of recognition performance than recall of patterns in set 2, which may be interpreted as support for the hypothesis that more patterns in set 1 were processed completely than were patterns in set 2.

In summary, the results of the pre- and post-stimulus instructions are not what they were expected to be, but they were also not at odds with the assumptions of model I in the Introduction.

Repetition Enhancement

The present research supports the decoding interpretation of repetition enhancement effects, i.e., improvement across trials, in an immediate memory paradigm. The encoding interpretation offered by Turvey (1967) for the effects of repetition are seriously challenged. In the Turvey study which utilized the Sperling post-stimulus cueing technique, a recognition demand and a peripheral retrieval process were present. The results of the present study suggest that both a recall demand and a central retrieval process are necessary to produce repetition enhancement. Central retrieval, whether invoked before or after stimulus presentation, still increases the likelihood of recall after 24 hours, that is, both pre- and post-stimulus instructions for recall increased the probability of recall later when compared with pre- and

post-stimulus instructions for recognition. However, only pre-stimulus instructions to recall produced significant improvement across trials in an immediate memory task. These results clearly support the predictions and model I, which state that a demand to recall will affect stimulus selection and hence performance on a test of immediate memory.

Perceptual Bias

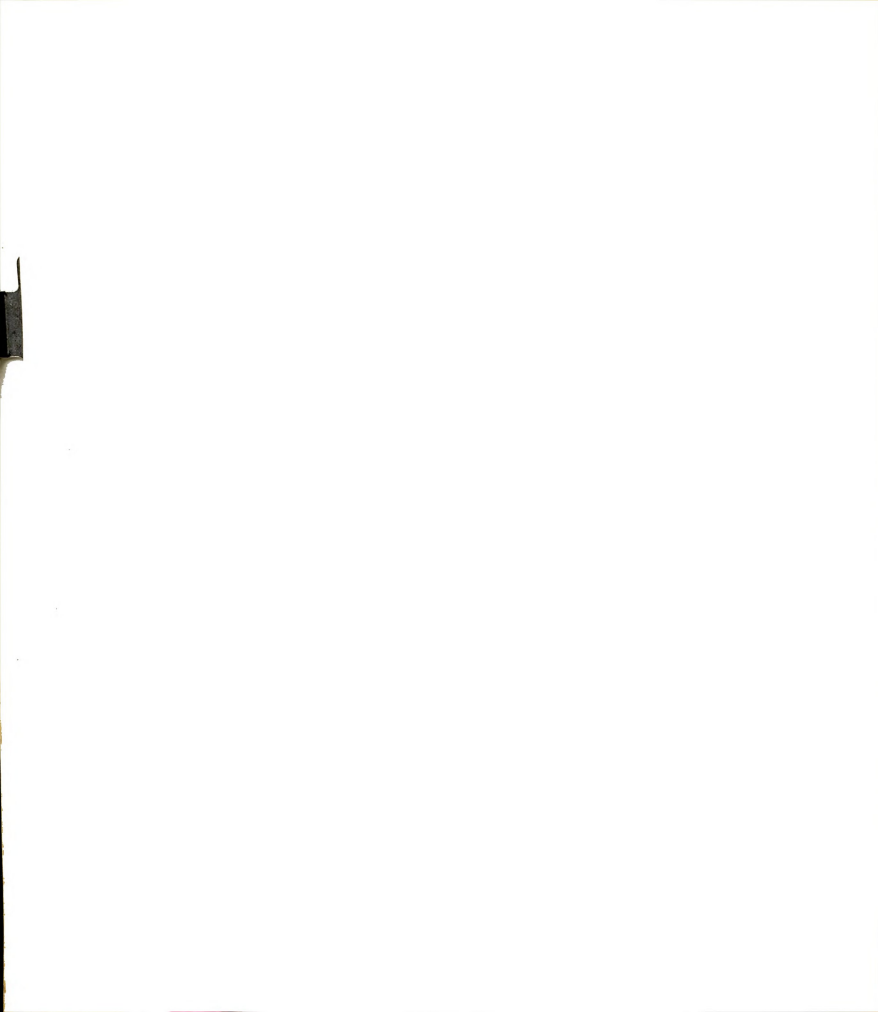
Sheehan (1966) demonstrated that images tend to be relatively accurate reproductions of original percepts. He had SS duplicate a complicated design immediately after presentation, then later. The later reproductions were more similar to the earlier reproductions than to the original designs. The similarity to the present findings is noteworthy. The theoretical question being asked by this type of comparison is important to many areas of psychology. Does the control of responding (whether the responding is implicit or observable) rest in the stimulus, or in the selective processes operating upon the stimulus? The importance of this question has been frequently recognized (e.g., Underwood & Reppel, 1962) by researchers in learning as well as researchers in perception. Thus, the fractional stimulus in P-A learning is frequently not the nominal stimulus, and these and related findings led Underwood to postulate a two-stage model of P-A learning. A related question involves the relative accuracy of the

selective or encoding processes: Is it possible that the selective processes can distort the information in the stimulus and that, under some conditions, these distortions will perseverate? Isolating the variables which affect these selective processes, and particularly the conditions under which biases will perseverate, is an important task for experimental psychology. Clearly, dynamic factors affect these selective processes (e.g., Smith, 1957; Fisher, 1954; Klein, 1956) but the present research suggests that information variables may also affect these processes. Specifically, there is a tendency for information which is organized in a way which can be encoded in one trial to be encoded in the same manner repeatedly. Therefore, if the encoding scheme is not highly accurate, the perceptual errors will perseverate. Also, if the exposure is brief, there will be no opportunity for negative feedback. This notion supported the lack of improvement across trials for pattern set 1, together with the higher scores for pattern set 1 when scored by an earlier reproduction (i.e., reproductions of patterns in set 1 were "accurate reproductions of the original percepts," just as in Sheehan's study).

Haber (1964b) found that information in a brief visual display which is encoded slowly tends to have more errors, and furthermore, that rehearsal of that information tends to increase these error tendencies. Applying Haber's findings to the present study, the concept of a negative

effect of a slow encoding rate fits quite well with the present interpretation. Encoding of unfamiliar visual information is probably a slow process, and any encoding errors are likely to perseverate and increase with rehearsal. The data in the present study support this, since all patterns except one received higher scores when using an earlier reproduction as a scoring standard than when using the original pattern on the 24-hour test. Thus, the errors in the original percept were duplicated in a test of memory.

It seems reasonable to suggest that this potential source of errors may be critical in learning to discriminate complex forms such as letters. Slow learners or retarded children, who perseverate more than normals, might benefit from having the selective or encoding processes carefully directed, to correct any perseverative encoding errors for which there may be no built-in corrective mechanisms. This is a suggestion which pulls together the observations that retarded children perseverate and have attention problems. The negative or debilitating effects of slow encoding might be the basic process deficit underlying both of these deficits.



Model II: A Final Attempt to Pull Together
the Many Concepts Relevant to Differentiat-
ing Recognition and Recall Processing

A recall trial can be different from a recognition trial in two ways. First, retrieval of central information is necessary for a recall trial and hence material acquired with a recall procedure is more likely to be retrievable later. Secondly, information which has been encoded may now re-enter the perceptual system via central retrieval. The present analysis assumes that the effects of central retrieval on further perceptual processing are similar to the effects of long-term memory as postulated by Broadbent (1958). That is, it is postulated that central information changes the nature and probability of coding of items in peripheral storage. (This is directly opposed to the assumption of Turvey [1967] that analyzed or encoded information does not interact with unanalyzed, or peripheral, information.)

Under a recall test demand, then, two things happen which do not happen under a recognition test demand.

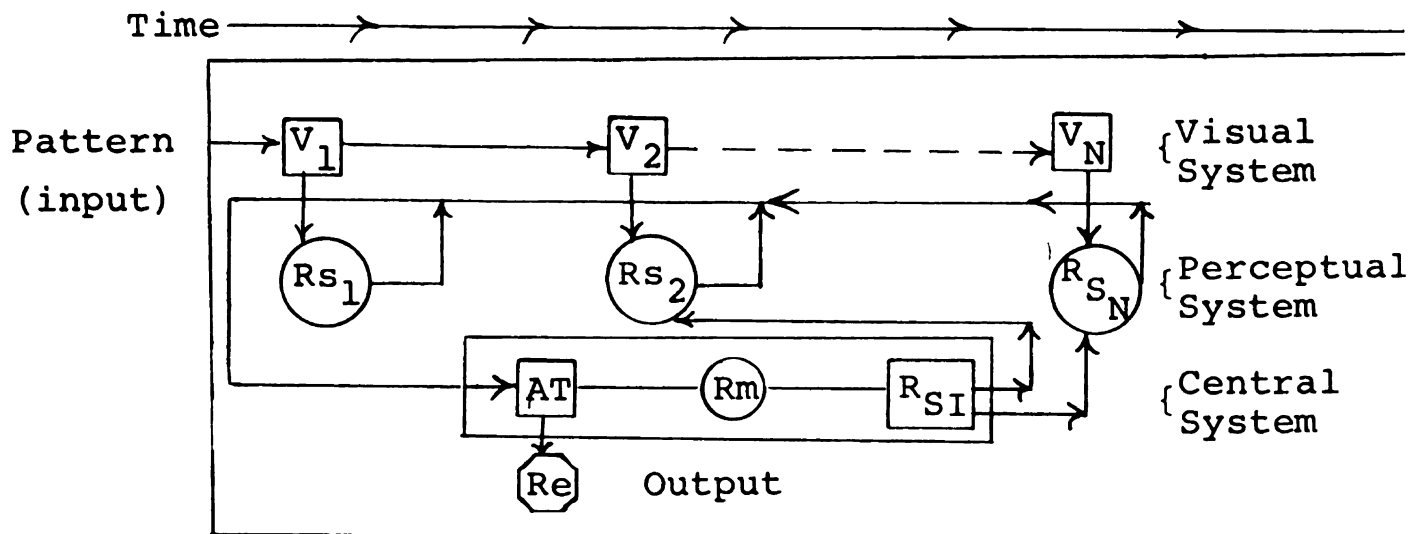
- (1) A central retrieval, or decoding process is set up.
- (2) Chunking, or grouping of more peripheral information under a differential response, occurs. This is because encoded information affects the retrieval of peripheral information during the recall test. Such information has been intentionally encoded prior to the recall test, when a recall demand was present.

The second effect is less obvious than the first. The actual process affected is the encoding process. The effect is motivational; the recall demand produces more encoding prior to test than the recognition demand. This encoding prior to test results in an interaction of central and peripheral information at test. It is postulated that this interaction produces "chunking," and chunking produces repetition enhancement, or improvement across trials. For this interaction of central and peripheral information to occur, it is necessary that S be motivated to refer to the visual system after the first encoding. If S thinks that the encoded information is sufficient to perform the task, he will not be motivated to compare information in visual storage with information in the central storage, and chunking, or repetition enhancement, will not occur. This is another way of saying that, if the encoding process does not utilize feedback, learning will not occur. A related idea has been proposed by Postman (1963) in his paper on the necessity of modifying the interference theory. There he pointed out that the processes of recall and recognition are constantly interacting: The high degree of sensitivity of recognition to differentiate and select information contributes to the efficiency of recall by continuously modifying the item reproduced in recall. A similar interplay was described by Smith (1957) in his review of the Leipzig school of perception: "Two concepts

supporting the (Leipzig) model are construction (from the available information, i.e., recognition) and reconstruction. . . . In order to describe the temporal organization of a percept, we use the method of reconstruction stages . . . i.e., various phases of the process of construction have been enticed prematurely to produce percepts fitted to the conceptual level of the end-product." Smith added that many experiments on perception, in attempting to isolate certain phenomena, have failed to recognize the importance of these feedback mechanisms which are a critical part of perception. The present analysis agrees with this point, and any model which attempts to describe the relationship between recall and recognition must include the interplay of the two processes over time. If recall involves interplay with recognition processes, then the acquisition of "recallable" information must involve the interplay of central information with the selective processes. The present analysis has attempted to clarify the nature of this interplay, adding that recall (or central information) may also modify recognition (peripheral retrieval, or encoding) when peripheral information is still available during the recall test. Any dual-process theory (e.g., Muller, 1913; Peterson, 1967) would handle the effects of acquisition condition on frequency of recognition and recall. Model II (below) is offered to illustrate the type of processing of information which is

suggested by both the 24-hour test performance and the performance during acquisition. Thus, repetition enhancement and independence of retrieval are explained by the processing illustrated in Model II.

A model which takes into consideration the rate of encoding, as well as the amount of decay in the visual system, would show the encoding process being activated following processing of the initially encoded material, with the central information now affecting further encoding. With a brief display of unfamiliar, binary information of the sort used in the present research, it is probably accurate to think of this secondary encoding occurring at least once. It should be evident that this process reoccurs as long as there is useful information in the visual system, or until S regards his percept as accurate. A general model is represented below, with sequence of perceptual (encoding) processes interacting with the visual and central systems. (More elaborate definitions of the various components are available in Appendix A.)



Time between R_{S1} and R_{S2} represents the time required to complete encoding of the information taken in by R_{S1} . The relationship between decay in the visual system (or other peripheral systems) and encoding is an important theoretical question which has been studied by several researchers (e.g., Mackworth, 1963a, 1963b; Haber, 1964a, 1964b). In the present model, encoding is the activity which begins with R_S and continues through R_m to R_{SI} . As Haber (1964b) has suggested, the processes of encoding are clearly selective, and if processing can describe selection effects without referring to the concept of attention, parsimony has triumphed. In the present model, R_S represents the information selection, and thus would be affected by differences in the discriminability of the information and

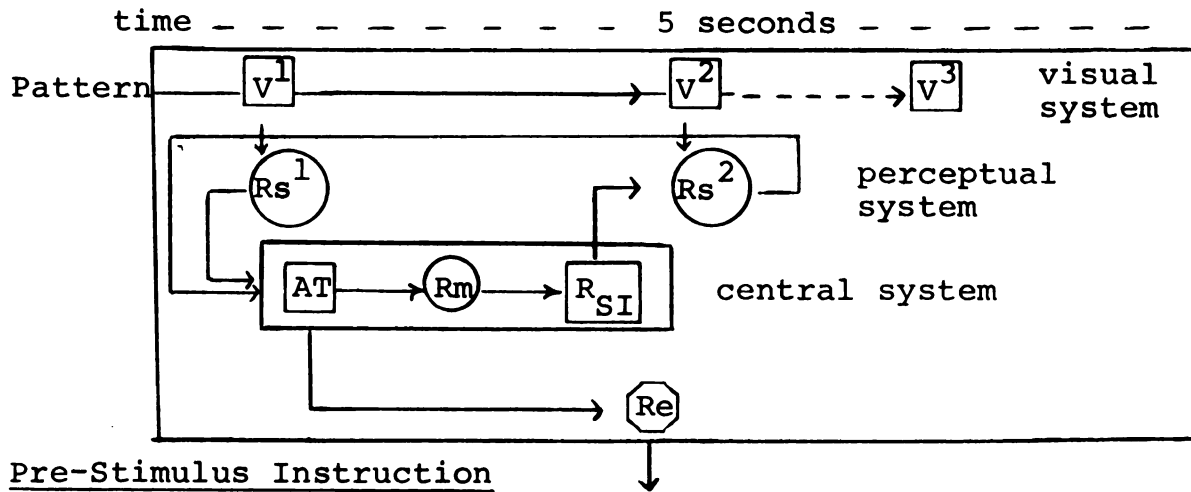
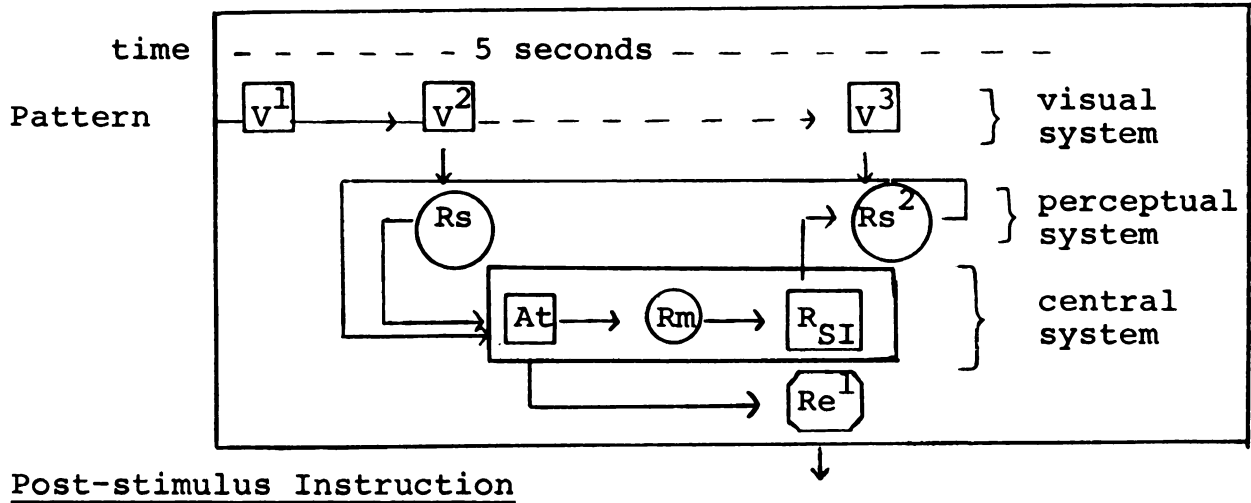
1

the associative strength of the selective response (such as a high versus a low association verbal item.) The Rs response also represents retrieval, whether central or peripheral, since the information transformed by the Rs response then goes to awareness (AT). The Rm component is a centrally stored response aggregate, similar in function to Sperling's recognition-buffer (1966). It is assumed that the motivational and contextual elicitors of the Rs response simultaneously elicit or call the centrally stored complex of R_{SI} cues, and in doing so, an associative conditioning trial takes place. On this trial, the Rs produced central cue is associated with the elements of the Rm aggregate. The details of this process are presented in Appendix A. The Rm component would be affected by the strength of association between items in a visual display, or between these items and their higher order response associates. Mackworth (1963) has reported that her data indicate that discriminability, strength of encoding response, and inter-item associative strengths are all important determinates of encoding rate, while Haber (1964b) has attested to the relationship between encoding speed and encoding accuracy of information in a brief visual display. It can be seen from this that rate of encoding is affected by peripheral (Rs) responding as well as central (Rm) responding. A critical assumption of the model is that decoding or central retrieval does not begin until the

encoding sequence is complete. Thus, information from a brief visual display has less chance of being decoded if it is encoded slowly. And if the information has not been retrieved from central storage, it will not be remembered on a recall test, but it will be remembered on a recognition test.

Model IIa: Applying Model II to
Explain Differences in Pre- and
Post-Stimulus Instructions

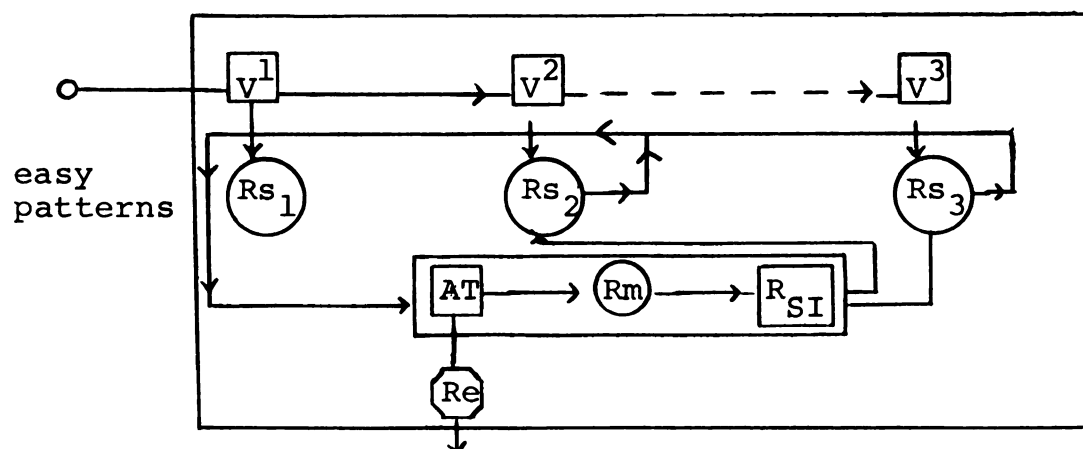
Processing under a recall instruction which is presented before (pre) or 5 seconds after (post) Stimulus is terminated. Systematic encoding does not occur until the instruction is given. Rs_1 begins the first systematic encoding of information. Rs_2 begins the second encoding, which involves interaction of central and peripheral information. The critical difference between the two (pre/post) conditions is the clarity of information in the visual system. For pre-stimulus instructions, the first intentional encoding occurs for V^1 which is before any information has faded. For post-stimulus instructions, the first intentional encoding is not until 5 seconds. for the pre-stimulus instructions, the second encoding will occur as soon as the first encoding sequence is completed, i.e., as a function of the encoding rate for a given item. For post-stimulus, the same function applies, but the information is 5 seconds delayed, since the first encoding was 5 seconds delayed.

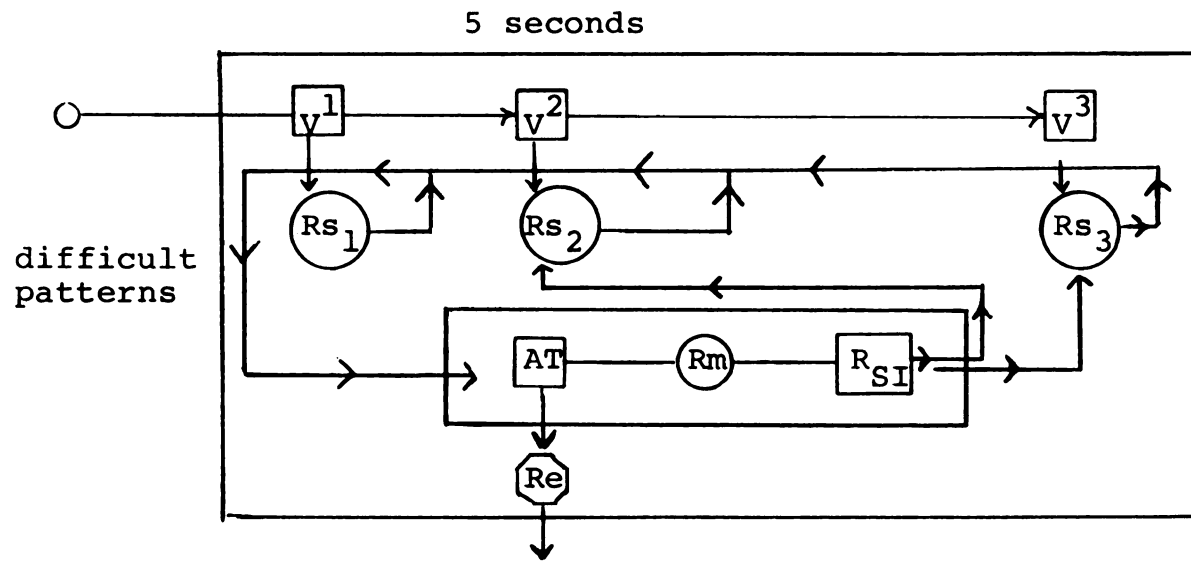




Model IIb: Applying Model II to
Explain Differences Between Easy
(Set 1) and Difficult (Set 2)
Patterns

Rs^1 represents the first sampling and encoding of information. For the post-stimulus instruction Rs^1 represents the random encoding prior to instructions, and Rs^2 represents the first systematic sampling 5 seconds after stimulus termination. For the pre-stimulus instruction, Rs^1 is the first systematic sampling and Rs^2 occurs following encoding of Rs^1 information. For easy patterns, more information is encoded randomly than systematically, while the reverse is true for difficult patterns.





EXPERIMENT II

METHOD

Subjects

The Ss were 25 members of a Psychology class at Michigan State University. The first 10 minutes of the class constituted the experimental session.

Apparatus

A manually operated Kodak slide projector, the same used in Experiment I, was used to present the series of six patterns in Experiment II.

Procedure

E passed out data sheets with the following written instructions to Ss: "The slides which you are about to see are patterns of black squares on a white background.

"Your task is to describe each pattern as it is presented to you. Think through or make the description as if you would have to reproduce the pattern from your own description at a later time (e.g., elaborate). Each pattern will be presented for 50 seconds. It is important for me to know the time it takes you to make the total description, and when you describe the various parts of

the pattern. Thus I'll identify the end of every 10-second period. At that time you should make a check mark above the word which you have just written. Write the parts of your description in the same order as you think them. When you finish completely with any given pattern description, try to identify how long it took you. For example, if you finished shortly after 10 seconds, the next announced time would be 20 seconds. Thus you would write out that you finished in less than 20 seconds. The longest you will have is 50 seconds. If you do not finish a pattern description say so.

"It is important that your descriptions be as concise as possible, and that you complete them as quickly as possible."

E then read the instructions aloud, and asked if anything needed clarification. E then proceeded to present each pattern for 50 seconds, followed by a 20-second rest period. At the end of the series, E debriefed the S on the purpose of the experiment.

Experimental Hypotheses

There is little evidence available to suggest how non-verbal visual information, such as the patterns used in Experiments I and II, is encoded. As Norman (1969) has pointed out, "Just how complex [visual] images are retained, and what the role of verbalization and rehearsal is . . . are unexplored problem areas in the study of memory."

Norman noted that almost all information processing models apply only to the retention of verbal materials. Two principles present in some models of verbal retention seem useful in the analysis of the retention of nonverbal materials. Most models include an initial encoding of visual information into auditory store (Norman & Waugh, 1968; Sperling, 1967; Turvey, 1967). And Sperling (1967) has added the idea that scanning of visual material must precede this auditory encoding.

Thus, at least two encoding processes seem possible: (1) patterns may be verbally described and stored in auditory form; (2) patterns may be scanned with a sequence of eye movements and/or other subtle motor responses providing encoding of visual information into a motor-kinesthetic form of storage. Possibly both processes could occur.

It seems likely that scanning provides at least an effective rehearsal technique in the present experiment, while verbal encoding would be a more effective device for long-term storage. Therefore, the following two postulates are offered.

Postulates. (a) If verbal encoding occurs with the undifferentiated visual materials used in these experiments, there will be evidence of a relationship between verbal encoding and long-term retention.

(b) Rehearsal of eye movements (scanning) may provide an additional source of information for a short period of time, i.e., for short-term memory. The present experiment is, of course, designed to test postulate (a).

To translate the postulates to experimental predictions, it is necessary to operationalize the relationship between the verbal description and the patterns. This is attempted by introducing the concept of the "Kernel." The term is borrowed from Chomsky's concept of the Kernel sentence, which is a simple, active, declarative sentence. By extracting the "Kernels" from each description, a numerical estimate of the amount of verbal differentiation required for each pattern can be made.

In this thesis, the operational definition of a "Kernel" is any word or phrase in a description of a pattern, which provides a definite restriction on the construction of the pattern, i.e., which reduces the degrees of freedom in constructing the pattern. In addition, the word or phrase must complete the following simple, active declarative sentence: "The part was . . ." ("part" refers to any aspect of the pattern being described).

The most common "Kernels" will refer to the location of, form of, or relationship between parts of the pattern. Thus the descriptive sentence, "The L-shaped part was in the lower left corner," could be made into two simple, active, declarative sentences, each adding a restriction

to the reproduction of the pattern: "The part was L-shaped," and "The part was in the lower left corner."⁵ Extraction of the Kernels gives a numerical estimate of the amount of verbal differentiation which may occur.

Each Kernel can be ranked for the statistical likelihood of its use in differentiating a pattern. The factors of $\bar{x}$ serial position of the Kernel in the total description, $\bar{x}$ latency of reproduction, and frequency of inclusion of the Kernel across descriptions, will be used in ranking each Kernel.

Since the number of different combinations of Kernels which can be applied to a given pattern is large, any estimate of the number of Kernels used to differentiate a pattern is a statistical estimate. The Kernels which appear in most descriptions of a given pattern are apparently representative of a strong tendency to verbally differentiate the pattern. Similarly, Kernels which appear early in descriptions also seem to reflect a stronger tendency for verbal differentiation than Kernels which appear later.

⁵The fact that these two Kernels were described in one sentence which relates them, suggests that a verbal coding of the visual material requires the storage of two chunks, while the visual information from which the coding was derived was only one chunk. Since the memory span is a limiting factor on central integration, this inefficient coding may indicate that verbal storage of this type of material would be effective only for rather simple patterns.

It should be clear that an attempt is being made here to assess the extent of verbal differentiation (and hence encoding) which is likely to occur for each pattern. To put this another way, Experiment II should provide a statistical indication of the selective effects of verbal differentiation on retention of these patterns, if verbal differentiation is utilized by Ss.

The examples below (Figure IIA) should clarify how a description would be divided into Kernels and ranked. A derived ratio of described-to-non-described elements is also presented.

A simple mathematical formula will give a ranking (R) for each Kernel, based on the mean serial position of the Kernel (X) across description, and the mean frequency (represented as $\% \times 10$) of occurrence of each Kernel across descriptions (Y). The formula is: $R = Y - X$. Only the first seven Kernels in any description will be rated, so the maximum value of X is 7. The range of ratings therefore is from -6 (if $Y = 1$ and $X = 7$) to +9 (if $Y = 10$ and $X = 1$).

Using the ranking of Kernels as the basic data, the following hypotheses are derived from Postulates (a) and (b) given above:

I. If patterns are encoded verbally, the aspects of the patterns which are described by the highest-ranked Kernels for each pattern will be reproduced more frequently

than other aspects of the pattern in the 24-hour test in Experiment I. For example, "A square in the upper left corner," would describe (1) shape, (2) in a location. The number of (accurate) Kernel-described parts on the 24-hour reproductions in Experiment I will provide an evaluation of this prediction, i.e., the number of parts of the pattern which can be derived from the Kernels.

RESULTS

The relationship of the verbal describability of parts of patterns, as discussed in Experiment II, to the likelihood of their reproduction in Experiment I is the primary interest in the present analysis. Elements in the 24-hour reproductions in Experiment I were placed in one of 5 categories, based on the descriptions and rankings. The categories included elements described by (1) first and second ranked kernels; (2) third and fourth ranked kernels; (3) fifth and sixth ranked kernels; (4) seventh and eighth ranked kernels; and (5) elements which were not described in the verbal descriptions. An element could receive a score of 0, 1, or 2 for each category. For example, if the information in both the first and second ranked kernels were contained in a reproduction, the pattern would receive a score of 2 for the first category. If the score contained only information described by the fifth kernel, but not by the sixth, the pattern would receive a score of 1 for the third category.

Two simple one-way analyses of variance were performed. The independent variable was the four categories of kernels, and the dependent variable was the number of

elements in the reproduced patterns in each of the four categories. (The analysis did not include the non-described elements for this reason. The difference between the number of described and non-described elements which were reproduced was clearly significant, but this difference is not clearly interpretable. And if the analysis included the non-described elements no conclusions could be drawn about differences between the described elements, which was of primary interest.) The two pattern sets were analyzed separately, to investigate the possibility that verbal codability was related to the recall differences found for the two pattern sets.

For pattern set 1, the difference between the different categories was highly significant ($F=15.58$, $df=632$, $p < .001$). Examination of the means for the four categories shows a distinct drop from category 1 to category 2, followed by increases in categories 3 and 4. These increases make up approximately half of the initial drop from categories 1 and 2.

For pattern set 2, the category effect was also significant ($F=7.20$, $df=303$, $p < .01$); but the difference in mean number of pattern elements reproduced at test between categories 1 and 2 was not quite as pronounced, and the mean for categories 3 and 4 remained approximately the same (see Figure 8).

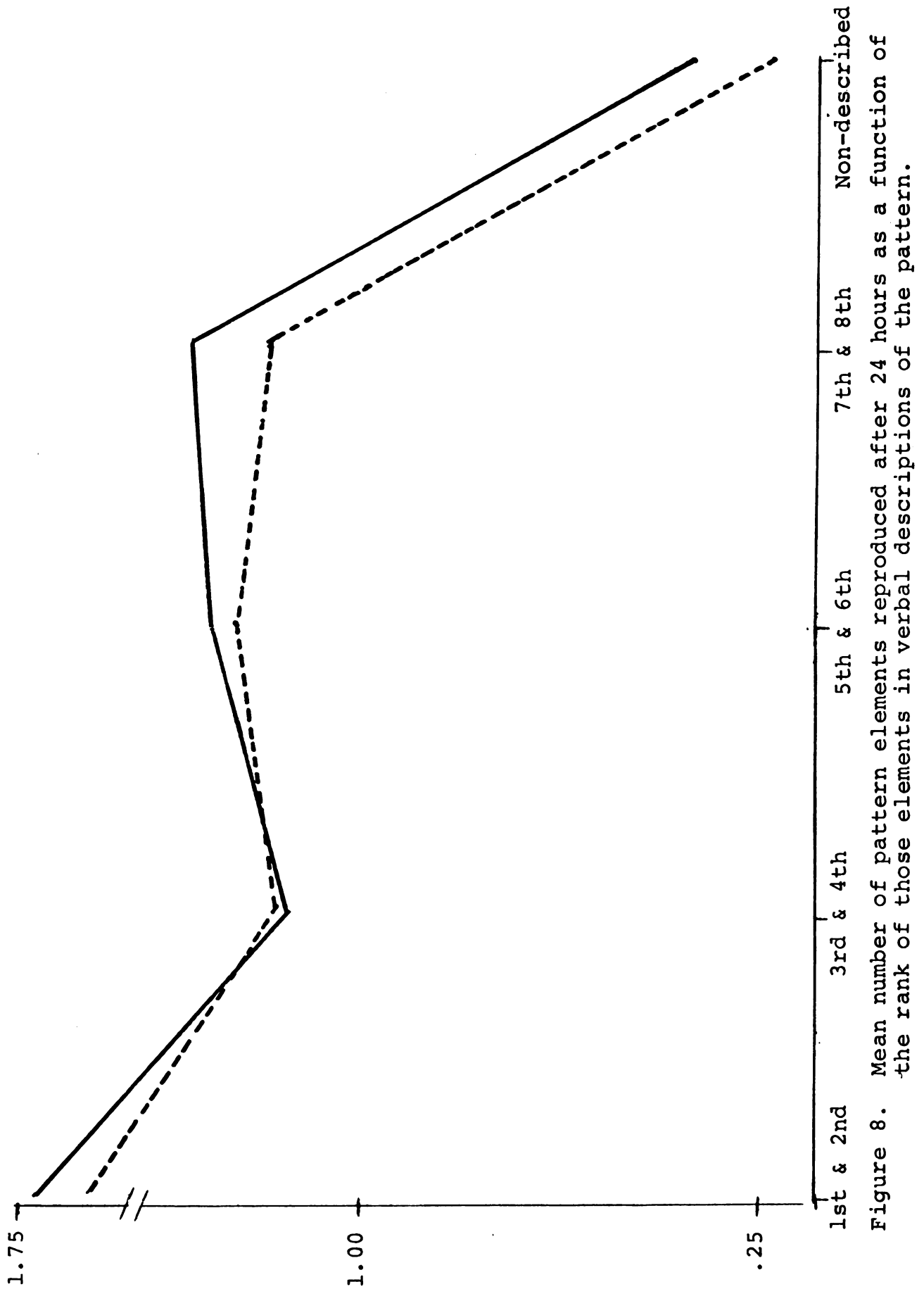
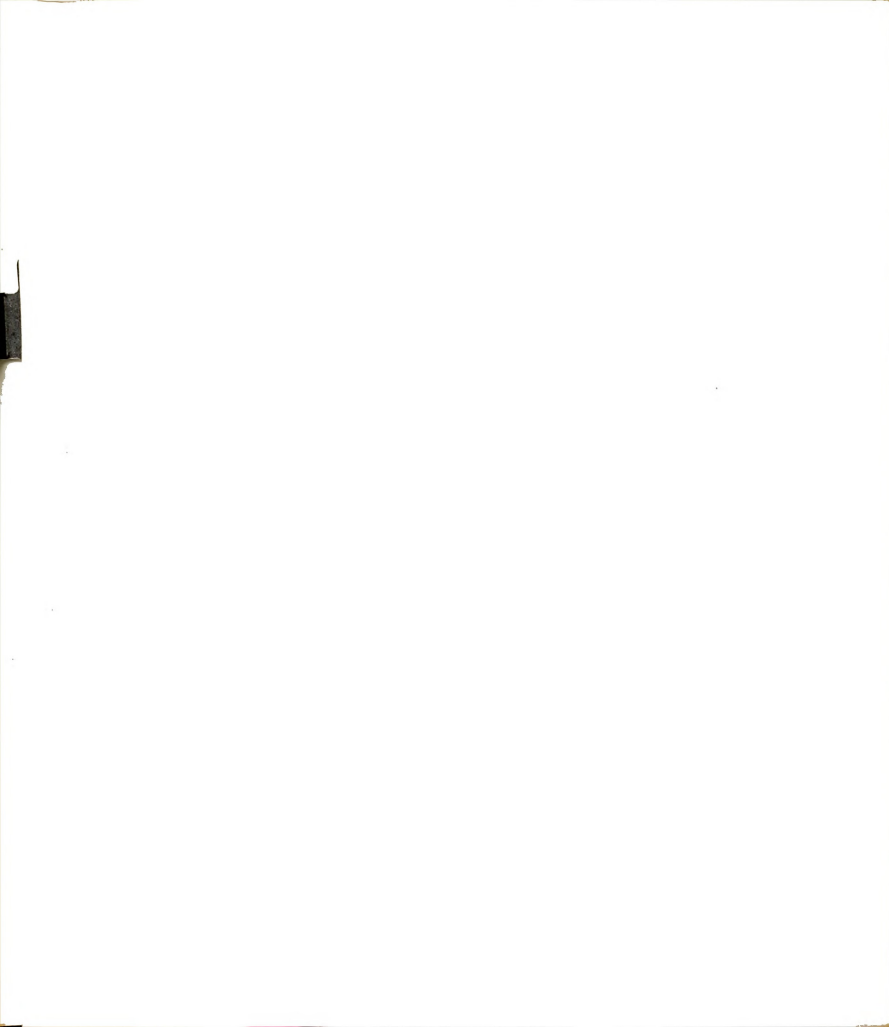


Figure 8. Mean number of pattern elements reproduced after 24 hours as a function of the rank of those elements in verbal descriptions of the pattern.



A cautious conclusion may be drawn from these analyses. The parts of a pattern which were described frequently and which occupied an early position in the descriptions were more likely to be reproduced in a 24-hour test of retention.

The prediction for Experiment II can be assessed as follows: the large ratio of described to non-described elements in the 24-hour reproductions supported the prediction, but the problems of interpretation remain. A simple analysis of variance showed that the most describable pattern elements in Experiment II proved to be the best remembered of the 24-hour reproductions in Experiment I.

DISCUSSION

Verbal Coding

Experiment II was designed to evaluate one of the basic assumptions about the materials used in Experiment I. The general assumption was that the randomly generated patterns were not codable through any existing coding scheme in the repertoire of most college Ss. It was specifically assumed that verbal coding would not be an efficient process with these materials. This assumption was important, because Experiment I attempted to assess ways in which a recall or recognition acquisition procedure would affect the acquisition of encoding responses. Since verbal coding is highly overlearned in college students, it would be difficult, it was argued, to observe the acquisition of encoding responses with verbal materials.

Haber (1964b) discovered some relevant facts about verbal coding using two coding schemes, one apparently more difficult or less efficient than the other. As was mentioned in the Discussion section for Experiment I the more difficult coding scheme was slower and produced more errors. Particularly relevant to the present experiment, however, is the fact that, for the efficient cueing scheme, there were no differences between free recall versus forced

order recall, either in the way Ss coded or in the number correct in the various positions. This was probably due to the much faster speed of encoding for the more efficient coding scheme, i.e., all items including the last ones, encoded before the visual system had lost its discriminable information.

A relatively inefficient coding system, by contrast, shows significant order effects with items encoded first under free recall being significantly more accurate than later items. This probably reflects the slower encoding rate for this coding scheme, i.e., the information in the visual system fades before accurate encoding of the later items can be completed.

For the present experiment, the implications are as follows. If the present visual materials can be efficiently encoded verbally, then there should be no order effects. Thus, if reproductions are based on verbally stored information, the reproductions should not show the effects of order. The assumption is made that verbal descriptions of the patterns mirror the order of verbal encoding.

It probably would benefit the reader to retrace the steps of this explanation. (1) An efficient verbal coding scheme shows no order effects (Haber, 1964b). (2) If the patterns were encoded verbally, verbal descriptions should approximate the order of this encoding. (3) If

reproductions do show an order effect, with the portions of the patterns described first and most frequently also reproduced most frequently, it will indicate that verbal encoding of these materials, if it occurred, did not tap a highly developed verbal coding scheme. In short, any encoding scheme which shows order effects is not highly developed. This is the most critical assumption which must be met, if we are to show that using unfamiliar materials allows us to observe the effects of variables upon the acquisition of encoding schemes.

The only significant result of Experiment II supports this assumption. The highest ranked kernels in the verbal descriptions of the patterns referred to parts of the patterns which were reproduced significantly more often after 24 hours than any other parts of the patterns. This indicates (1) that each pattern has particular elements which have a high probability of being encoded first, or at least sooner on the average, than other elements of that pattern, and (2) the order effect noted by Haber with his least efficient coding system were found here. According to the above analysis, the order effects indicate that encoding of the pattern was slow and was affected by decay in the visual storage system.

Many more "described" than "non-described" parts of patterns were remembered, but the descriptions included

the most prominent parts of the pattern, so a problem of interpretation remains.

The Glanzer and Clark studies (1963a, 1963b) have the same problem of interpretation. The high correlation between recall and length of description found by Glanzer and Clark (1963a, 1963b) does not necessarily imply that their items were encoded verbally. Glanzer and Clark's interpretation was that the brevity of the descriptions of patterns was the critical factor in the accuracy of their reproductions. As Neisser (1970) has pointed out, the symmetry, simplicity, or redundancy of the patterns could affect the accuracy of their recall, as well as the length of their description, and thus provide a spurious correlation. The methodology of Experiment II is equally unsuitable for distinguishing between encoding schemes.

A better technique for evaluating the encoding process for the materials used here would be to have the same Ss reproduce, and then describe, the patterns. This would ensure that individual differences would not obscure the results. However, the problem of interpretation suggested in the above paragraph would still remain. More interpretable results would come from a procedure which would measure the rate and order of both reproducing and describing different parts of the patterns. Close correspondence between these would be clear evidence that the verbal descriptions accurately reflect the encoding process.

In conclusion, the evidence suggested that the patterns were encoded slowly, since there were significant order effects. Although these findings are not useful in making definitive comments on the encoding of the patterns, they do provide assurance that the encoding processes were slow and inefficient, suggesting that the attempt to minimize the effects of powerful coding tendencies and prior learning by using unfamiliar materials was successful.

Conclusions

The attempt to distinguish the effects of the implicit demands of recall from those of recognition, and to distinguish the effects of central retrieval from those of peripheral retrieval was highly successful. The effects of the demands were interpreted as follows: The recall demand increases the likelihood of encoding, prior to retrieval and hence produces an interaction of central retrieval of information with peripheral retrieval. This seems to be the necessary condition for chunking. Chunking, in turn, produces improvement across trials, by increasing the efficiency of encoding. The recognition demand decreases the likelihood of encoding, prior to retrieval and hence encourages peripheral retrieval. The recall demand (when compared with the lack of any specific demand, i.e., the pre- versus post-stimulus recall conditions) produced greater improvements over trials, rather than an advantage in accuracy on all trials.

The effects of central versus peripheral retrieval were the most impressive data collected, demonstrating that, independent of the encoding effects of demands and pattern difficulty, the patterns which required central retrieval on the STM task were remembered equally well in both recognition and recall tests, while patterns which required peripheral retrieval on the STM task showed a highly significant difference between the two measures. This result clearly indicates that the method of acquisition of information will affect its availability for recall in a different way than could be accounted for by a uni-process response threshold model of memory, and points to the necessity of a multi-factor conception of memory processes.

Results reflecting differences between pattern sets supported Haber's (1964b) theorizing about encoding, i.e., that inaccuracy in encoding will be magnified by rehearsal, resulting in greater inaccuracies in long-term memory as a function of the degree of inaccuracy in original encoding. Hence, set 1 patterns were less accurate during STM tests, and showed more improvement than set 2 patterns, when scored by a former reproduction instead of the actual standard, on the 24-hour test.

REFERENCES

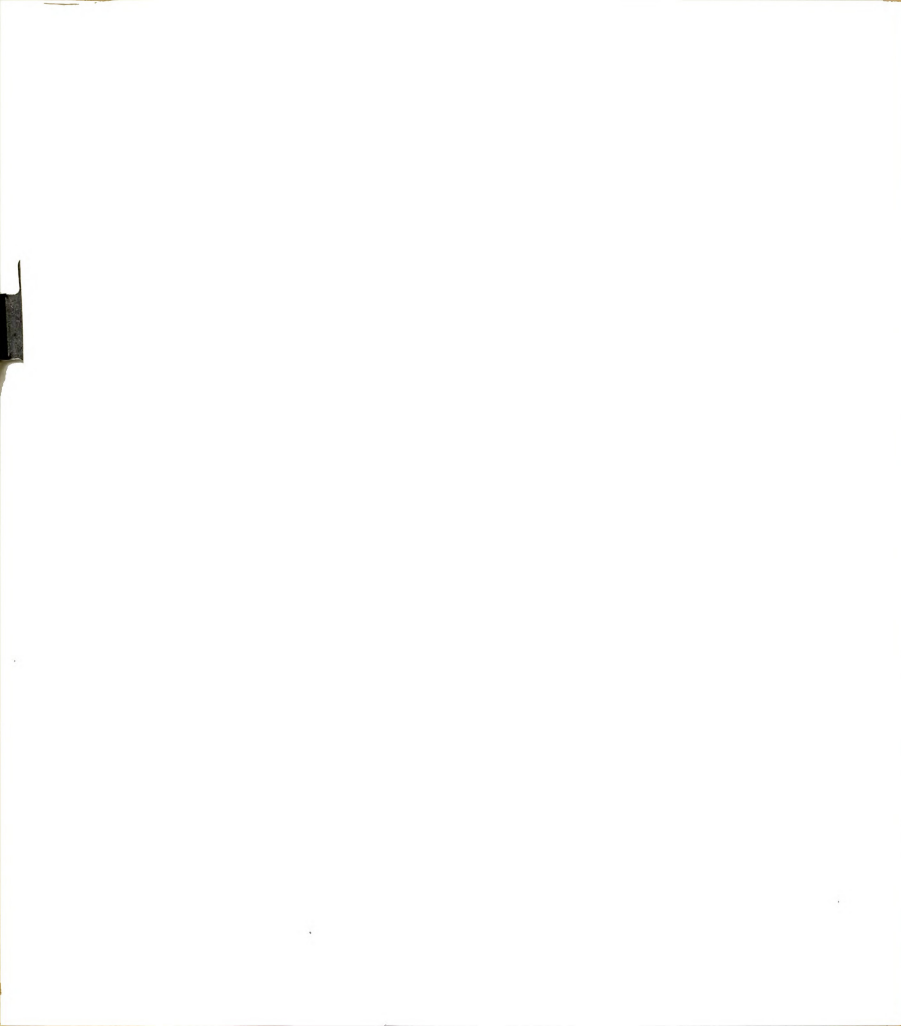
REFERENCES

- Averbach, E. The span of apprehension as a function of exposure duration. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 60-64.
- Bahrick, H. P., & Bahrick, P. D. A re-examination of the inter-relations among measures of retention. Quarterly Journal of Experimental Psychology, 1964, 16, 318-324.
- Bartlett, F. C. Remembering. Cambridge (England): Cambridge University Press, 1932.
- Bergen, H. Matter and memory. Trans by N. M. Parl & W. S. Palmer. New York: Macmillan.
- Bower, G. H. A multicomponent theory of the memory trace. In K. W. Spence and J. T. Spence (Eds.) The psychology of learning and motivation. Vol. I. New York: Academic Press, 1967.
- Broadbent, D. E. Perception and communication. New York: Pergamon Press, 1958.
- Broadbent, D. E. Flow of information within the organism. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 34-39.
- Dale, H. C. A. Response availability and short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967a, 6, 47-48.
- Dale, H. C. A. Familiarity and free recall. Quarterly Journal of Experimental Psychology, 1967b, 19, 103-108.
- Davis, D. R., Sutherland, N. S., & Judd, B. Information content in recognition and recall. Journal of Experimental Psychology, 1961, 61, 422-428.
- Denny, M. R., & Lipman, L. Comment on the role of the inter-trial interval in serial learning: A clarification. Psychonomic Science, 1966, 4, 234.

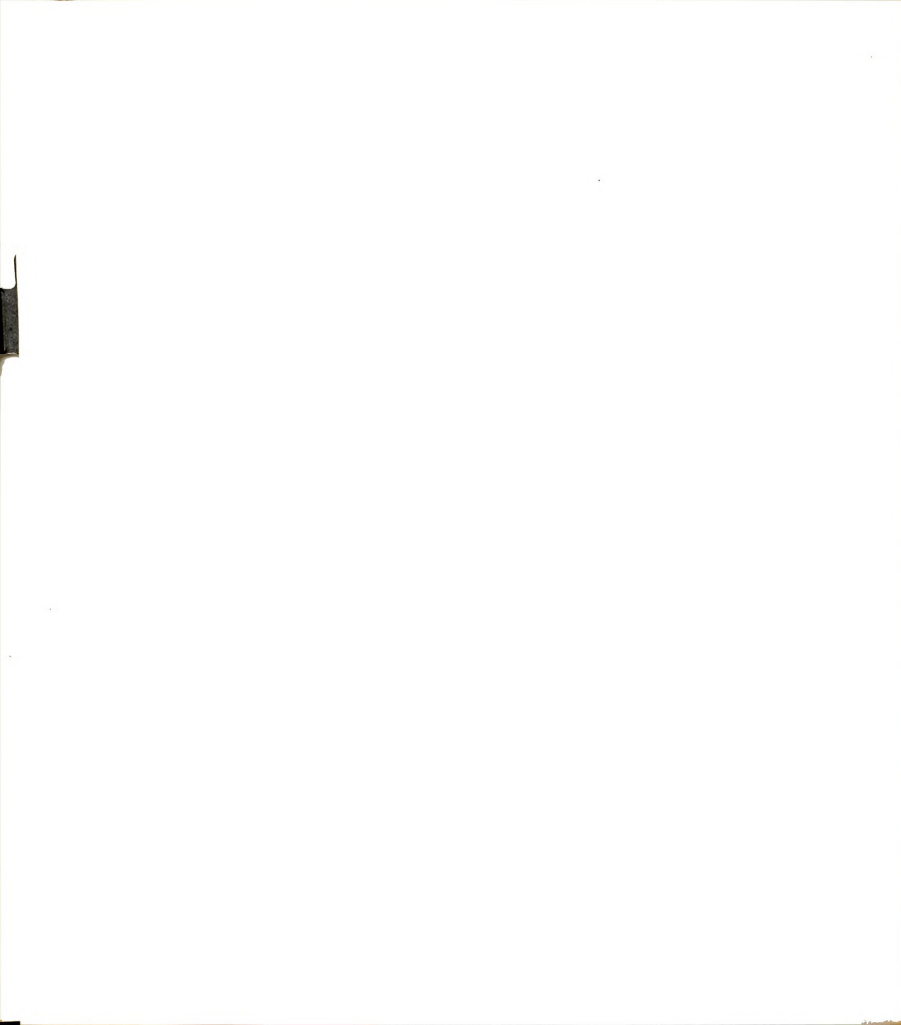
- Estes, W. K., & DaPolito, F. Independent variation of information storage and retrieval processes in paired-associate learning. Journal of Experimental Psychology, 1967, 75, 18-26.
- Fant, G. Auditory patterns of speech. In W. Wathern-Dunn (Ed.) Models for the perception of speech and visual form. Cambridge: MIT Press, 1967.
- Fisher, C. Introduction: Preconscious stimulation in dreams, associations, and images. Psychological Issues, 1960, 2(3), 1-40.
- Gibson, E. J., Bishop, C. H., Schiff, W., & Smith, J. Comparison of meaningfulness and pronounceability as grouping principles in the perception and retention of verbal material. Journal of Experimental Psychology, 1964, 67, 173-182.
- Glanzer, M., & Clark, W. H. The verbal loop hypothesis: Binary numbers. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 301-309.
- Haber, R. N. A replication of selective attentives and coding in visual perception. Journal of Experimental Psychology, 1964a, 67, 402-404.
- Haber, R. N. The effects of coding strategy on perceptual memory. Journal of Experimental Psychology, 1964b, 68, 357-362.
- Hall, J. F. Learning as a function of word frequency. American Journal of Psychology, 1954, 67, 138-140.
- Hebb, D. O. Distinctive features of learning in the higher animal. In J. F. Dolafresnage (Ed.) Brain mechanism and learning. London: Oxford University Press, 1961.
- Hull, C. L. The concept of the habit-family hierarchy and maze learning. Psychological Review, 1934, 41, 33-52.
- Kintsch, Walter. Learning, memory, and the conceptual processes. New York: John Wiley, 1970.
- Klein, G. S., Spence, D. O., Holt, R. R., & Gourevitch, S. Cognition without awareness: Subliminal influences and conscious thought. Journal of Abnormal Soc. Psychology, 1958, 57, 255-266.

- Libermann, A. M., Cooper, F. S., Harris, K. S., MacNeilage, P. F., & Studdert-Kennedy, M. Some observations on a model for speech perception. In W. Wathern-Dunn (Ed.) Models for the perception of speech and visual form. Cambridge: MIT Press, 1967.
- Liss, P., Reeves, A., & Wildfogel, J. Paper delivered at 42nd Annual E.P.A. Meeting, April 15, 1971.
- Mackworth, J. F. The duration of the visual image. Canadian Journal of Psychology, 1963a, 17, 62-81.
- Mackworth, J. F. The relation between the visual image and post-perceptual immediate memory. Journal of Verbal Learning and Verbal Behavior, 1963b, 3, 75-85.
- Mandler, G. Response factors in human learning. Psychological Review, 1954, 61, 235-244.
- Melton, R. Implications of short-term memory for a general theory of memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 1-21.
- Miller, G. A. The magical number seven, plus or two. Some limits on our capacity for processing information. Psychological Review, 63, 81-97.
- Neisser, U. Cognitive psychology. New York: Appleton-Century-Crofts, 1967.
- Noble, C. E. An analysis of meaning. Psychological Review, 1952, 59, 421-430.
- Norman, D. A. Memory and attention. New York: John Wiley, 1970.
- Norman, D. A., & Waugh, N. C. Stimulus and response interference in recognition memory. Journal of Experimental Psychology, 1968.
- Peterson, L. R., & Peterson, J. J. Short-term retention of individual verbal items. Journal of Experimental Psychology, 1959, 58, 193-198.
- Peterson, L. R. Search and judgment in memory. In B. J. Kleinmuntz (Ed.) Concepts and the structure of memory. New York: John Wiley, 1967.
- Postman, L., Jenking, W. O., & Postman, D. L. An experimental analysis of active recall and recognition. American Journal of Psychology, 1948, 61, 511-519.

- Postman, L. Does interference theory predict too much forgetting? Journal of Verbal Learning and Verbal Behavior, 1963, 2, 40-48.
- Sherman, M. F., & Turvey, M. R. Modality differences in short-term serial memory as a function of presentation rate. Journal of Experimental Psychology, 1969, 80(2), 335-338.
- Sheehan, D. W. Functional similarity of imaging to perceiving: Individual differences in vividness of imagery. Perceptual Motor Skills, 1966, 23, 1011-1033.
- Shephard, R. N. Recognition memory for words, sentences, and pictures. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 156-163.
- Smith, G. J. W. Visual perception: An event over time. Psychological Review, 1957, 64, 306-313.
- Sperling, G. The information available in a brief visual presentation. Psychological Monographs, 1960a, 74(11), 498.
- Sperling, G. Successive approximations to a model for short-term memory. Acta Psychologica, 1967, 27, 316-324.
- Treisman, H. M. Monitoring a storage of irrelevant messages in selective attention. Journal of Verbal Learning and Verbal Behavior, 1964a, 3, 449-459.
- Treisman, H. M. Selective attention in man. British Medical Bulletin, 1964b. 20, 12-16.
- Turvey, M. T. The effects of rehearsing analyzed information upon the retrieval of unanalyzed information. Psychonomic Science, 1966, 6, 365-367.



APPENDICES



APPENDIX A

ASSUMPTIONS OF THE MODEL

APPENDIX A

ASSUMPTIONS OF THE MODEL

INTRODUCTION

The present analysis postulates that two kinds of learning, differential learning and mediational learning, can explain the relationship between the effects of recall and recognition demands on retention.

Mandler's theory of response factors in human learning is conceptually similar to the present analysis, and several of his definitions are included in this paper. Those portions drawn from Mandler's treatise will be identified by quotations, with my modifications identified by parentheses.

Four conditioning paradigms are considered. They represent four theoretical situations: (a) Learning under a recall demand situation; (b) Learning under a recognition demand situation; (c) Retention under a recall test

condition; and (d) Retention under a recognition test condition.

Understanding the following definitions is essential to understanding the paradigms.

Basic Theoretical Orientation

Learning--The change in behavior from trial N to trial N + 1 is commonly accepted operational definition of learning (e.g., Broadbent, 1963). Melton (1963) pointed out that at least three theoretical events may represent the behavioral change from trial N to trial N + 1: The parenthetical portions represent elaboration by the present writer of the three theoretical events described by Melton.

1. The events on trial N may cause a structural change, i.e., the formation of a memory trace. (A necessary condition for structural change is the occurrence of a response which differentiates some stimulus from the total impinging stimulus array. This is the first component in the encoding sequence.)
2. During the interval from trial N to trial N + 1, the memory trace is stored in some way. (This storage activity affects the availability of the trace. A trace which is highly available is essentially cross-referenced, i.e., there are many potential ways of cueing the memory trace. The storage activity is the arousal of a central associative aggregate by the stimulus trace. This arousal is the second component in the encoding sequence, similar in function to Sperling's recognition-buffer.)
3. The events on trial N + 1 are responsible for the utilization of the memory trace. (The utilization of the stimulus trace on trial N + 1 involves the arousal of a central associative aggregate which in some way cues the memory trace. A differential

response then selects the central information from central storage. This will be referred to as decoding.)

In summary, for learning to take place, it is necessary for (1) a stimulus trace to elicit a differential response which causes the formation of a memory trace (first stage of encoding); (2) the memory trace is stored in reference to existing associative systems (second stage of encoding) which will determine its availability on trial $N + 1$; (3) the stimulus trace on trial $N + 1$ elicits central activity, which cues the memory trace, which is then selected (decoding). The behavior on trial $N + 1$ is elicited by the "convergent causal event" (Broadbent, 1963) of the cued memory trace, rather than the original stimulus. Stimulus situations which are quite dissimilar in pure physical determinants elicit the same empirical response if the mediating memory trace is cued by both. For example, spoken directions to a person alone in a room may have the same behavioral effect as written directions in a crowded room. The memory trace aroused by the two dissimilar stimulus events cues the same response (Broadbent, 1963).

Analysis of the three theoretical events discussed above offers many important questions for the study of retention. How does the extent of the (encoding) central response aggregate aroused by the stimulus trace on trial N affect the effectiveness of its storage? How is trace

retrieval affected by the associative storage system? Is the specificity of the stimulus trace encoding response link critical in the retrieval stage? Understanding the variables which affect trace formation, storage and retrieval is clearly essential to understanding the differences between recall retention and recognition retention. Before pursuing these questions further, an elaboration of the conception of learning which is basic to this thesis will be made.

Two-process Learning

In studying a problem in memory, a decision must be made to restrict the area of analysis. An attempt at analysis of the pathways through which information flows can reach levels of complexity not appropriate to the problem of interest. It is essential that the researcher keep the goals of the analysis in mind. In this spirit, it was decided that the distinction between learning styles with a recognition and a recall task could most efficiently be made with a two-process conception of learning.

An example of an earlier two-process approach to the analysis of memory is Underwood's model of P.A. learning. Underwood (1960a) postulated that a S in a P.A. learning task goes through two stages of learning, the response learning stage, and the associative learning stage. The acquisition of the response item, Underwood

suggests, is independent of the associative learning stage. To evaluate this theorem, Underwood compared a recognition measure of acquisition with recall measure. The reasoning for this approach is as follows: A recall measure would indicate that both response learning and associative learning have occurred. A recognition measure would indicate only that associative learning had occurred. If an item was remembered on a recognition trial but not on a recall trial, it could be assumed that associative learning had occurred but response learning had not. This example suggests that a two-process analysis is useful in distinguishing the difference found between a recognition and a recall measure of retention.

Underwood has not elaborated on his concept of response learning, except to say that response learning is the ". . . Acquisition of the response item" (1960a). The nature of response learning is an important consideration in the present treatise. A model of response factors will be presented below in which the definition of response learning will be treated in detail. The model will assume two basic learning processes: (1) the acquisition of cue-producing, differential responses, and (2) the acquisition of mediational (associative) responses that form central response aggregates which are mutually aroused by a differential response-produced cue.

DEFINITIONS

Rs--A differential response is a peripheral, cue-producing response which differentiates some aspect of peripheral sensory information.

The concept of a cue-producing response has appeared in several forms in psychological theory. Most of these concepts have involved the production of peripheral information as a necessary component to the maintenance of complex behavior. Hull's rg was postulated as a mediator of elaborate motor response chains in rats. The motor theory of thought (Brown, 1914) is supported by physiological research with human Ss. This research showed that normal Ss had increased activity in the motor or articulatory area of speech while dreaming, as shown by EMG measures. Even more compelling was the finding of similar increases in EMG in the fingers of dreaming deaf-dumb Ss, whose principle means of communication was with their hands. A more current motor theory (Libermann et al., 1967) suggests that the inconsistent input of acoustical signals is translated into an articulation code with internally generated signals. The feasibility of such an approach is supported by a study by Fant (1967), in which Ss were able

to shadow a phonemic signal with very little delay. Also, Noble (1952) has suggested that variations in the motor skill of pronunciation of verbal material is a major variable in determining the relative ease of response learning of these items. This is consistent with Libermann's (1967) theory, and with the present analysis, which stresses the importance of the cue-producing response in retention.

To clarify what is meant by the acquisition of a differential response, a set of assumptions from Mandler's theory of response factors follows:

1. "A stimulus is differentiated from other stimuli when it evokes a response different from the response evoked by other stimuli. The response can belong to any class of responses, i.e., verbal, motor or symbolic, depending upon the original learning experience of the individual." (Perceptual learning and differential learning as described here are not distinguishable.)

2. "When identical Rs responses have frequently occurred for two or more stimuli, these stimuli will be perceived as identical." (This implies that the basic determinants of perception are the Rs-produced cues.)

3. "Several different differential responses can be associated with any one stimulus, and, other things being equal, they will differ only in terms of the

probability of their evocation, which is a function of (prior learning), as in Hull's habit family hierarchy (1939)."

Hebb's (1949) notion of phase-sequencing, i.e., the integration of perceptual units through facilitation of the mediating motor response, is considered a reasonable behavioral principle for Rs as conceived here. That is, one Rs may become a sub-response to a larger Rs. For example, both a phoneme (auditory signal) and a letter (visual signal) may be differentiated individually, or they may become part of a larger visual or auditory unit, perhaps a word. Each Rs response occurs appropriately to the total stimulus. The number of trials in which the stimulus elicits each Rs response, in a given contest, will provide a habit-hierarchy for a set of Stimulus-Rs connections.

Rs_I--An Rs-produced cue which is part of an Rm (defined below), and may be differentiated by an Rs response.

Rm--A central, response aggregate which is aroused when an Rs response occurs. The motivational and contextual elicitors of the Rs response will elicit the firing of an Rm aggregate with 1 to N Rs_I cues. These Rs_I cues are, in a sense, secondary encoders of the sort suggested by Bower (1967). The Rs_I cues may be associated with cues produced by different effectors than the original Rs response, or

they may be produced by similar effectors. This means that an Rm aggregate may allow cross-modality storage of information. Mandler's theory of response factors also provides assumptions which specify the acquisition of a response aggregate, or Rm. The following are Mandler's assumptions concerning the nature of the Rm aggregate.

a. "Many responses performed by human organisms consist of aggregates of several subresponses which may be innate or acquired."

b. "With successive repetitions of a response aggregate, the separate responses eventually become stimuli for each other such that any part of the response aggregate will tend to evoke the whole response aggregate. This process will be referred to as response integration."

c. "Integration is an increasing function of repetitions of the response aggregate." (The present statement includes temporal factors as relevant to the formation of response aggregates. Specifically, it is postulated that the formation of response aggregates is also an increasing function of the amount of time during each repetition, that S is able to sustain his attention or concentration (perhaps through rehearsal) upon the response aggregate. The notion is supported by work on temporal factors in memory (Norman & Waugh, 1968). Empirical evidence that response integration is facilitated by the amount of time which the stimulus is available was found by Mackworth (1963a). In



this study increasing the duration of presentation increased the accuracy of serial recall in a memory span paradigm with 8 and 16 digit strings in two ways. Up to one second, accuracy increased as a steep linear function. From 1-4 seconds, a logarithmic function appears, which is replaced by a less steep linear function beyond 4 seconds. The present analysis interprets the second linear function as an indication that response integration was increasing during the additional time (beyond 4 seconds) available to S.)

d. "The integration or association of two responses proceeds more rapidly than the association of a response to a stimulus. Thus, it is easier to learn a new response to a stimulus which already evokes a differentiating response (Rs) than to a new unfamiliar stimulus." (This is a critical assumption to the present analysis. To explain the effects of meaningfulness in a P-A paradigm, for example, this analysis would point out that even with low-meaning verbal items, an Rs response would be elicited by some aspect of the stimulus item, and hence be easily associated to the response item. Meaningfulness of the stimulus item would have little effect on P-A acquisition. On the other hand, the response item must be recalled completely in P-A acquisition, and the stimulus item must be recalled in backward recall. Thus, a highly meaningful item would require no additional differential (Rs) learning, while a

lo-meaning item would require considerable Rs learning, e.g., pronouncing it, for integrating the already differentiated sub-responses in the item.)

f. "The integration of a response aggregate proceeds more rapidly when the response units belong to the same effector modality. Differences in effector modality refer to differences in effector organs utilized in making a response. Thus, it would be easier to integrate two verbal responses than a verbal and a motor response."

Rm_d--When an Rm aggregate to an Rs-produced cue is one of two possible associates to the situation, i.e., a dichotomous choice, a special kind of storage occurs. This type of encoding will be designated Rm_d, to indicate that a minimal Rm response aggregate has been elicited by Rs. It should be noted that this type of associative response only provides effective storage for a memory situation in which decoding will not be necessary in retrieval, i.e., a recognition test. The Rm aggregate contains much of the contextual information which provides adequate cueing for the desired Rs_I. The Rm_d is obviously void of this critical contextual set of associates. The idea that a typical associative response is minimal when a recognition demand is present is supported by Kintsch's (1970) conclusion that "the single memory trace appears to be the appropriate unit for analysis in the case of recognition memory, while recall is determined by interrelationship among items both

within a list and between different lists." The point is that the response aggregate elicited by a recognition demand will be minimal, thus minimizing the opportunity for interference, but also minimizing the availability of the memory trace for recall.

AT--Central reverberation of Rs responses. The number of Rs produced cues in AT must be sub-span. (This is not elaborated upon here, though part of the model, AT is not part of the recall-recognition analysis.)

rs--A partial Rs response. In an experiment, Rs responding will include the differentiation of the situational cues, as well as the more specific differential response to individual stimuli in the experiment. The general situational and motivational components of Rs responding are constant across all items (stimuli) in the experiment. In reference to a non-experimental situation, the common differential elements are the basis for concept formation, i.e., motivational and situational cues which are common to all of the specific items and can provide the basis for an abstract concept which represents this communality. For example, the concept "tool" was formed, according to this analysis, by the common kinesthetic and motivational elements of most situations in which various tools are used. Thus, the inverse of the process described under "Rs" takes place. Instead of an Rs becoming a

sub-component of a larger "Rs," a sub-component of a larger Rs becomes a smaller Rs.

It is useful to distinguish these two processes, by designating the latter as rs learning. This differentiation is useful, because rs learning is the basis for a retrieval system in recall.

rm--A central, information search. The rs response produces cues which fire the different Rm's (response aggregates) which are appropriate. The probability of a particular Rm being fired is a function of the habit strength of the particular rs--Rm association. For example, the first time in a serial list would be specifically associated with the rs (differential response to the general experimental situation). Other items would be progressively less dependent upon the rs component, and more dependent upon the cues produced by the specific Rs response-produced cue from the previous item. Primacy, according to this analysis, is due to more effective cueing or retrieval of early items. This is consistent with the findings of Denny and Lipman (1966) on the importance of the distinctiveness of ITI in serial learning.

The decoding process is defined as an information search, with the rs response firing N response aggregates. These aggregates share the rm aggregate as a common link. The models and examples which follow should clarify some of the relationships described here. Class recognition

(Kintsch, 1970), and the rare occurrence of intrusion errors from inappropriate contexts (Peterson, 1967) support this construct.

Re--An effector response. Most often this is assumed to be the verbal-motor (articulation) effectors, since most information is retrieved by verbalization. However, any translation of internal information involves an effector response. It is assumed the translation only takes place for information in short term storage (designated "AT" in the model).

Postulates

I. Storage and retrieval are independent of perceptual learning, as defined above. The storage factors, i.e., the parameters of the R_m aggregate (size, probability of arousal), will determine the availability of the Rs_I produced cue. (The familiarity aggregate is the largest, and hence that information is the least available, see III below). The retrieval factor, i.e., the conditioning of the differential response to the Rs_I cue in the R_m aggregate, will determine the probability that the Rs_I cue will be retrieved. (A comprehensive treatment of mnemonic devices and their relation to possible storage and retrieval processes in Norman (1969) provides an appropriate set of examples for this postulate.) Therefore, the difference between Rs -produced information and Rs_I (which

is a measure of perceptual learning) will not be related to the probability of recalling or retrieving the information in Rs_I at a later time (measure of mediational learning).

II. The first stage of encoding, i.e., the attaching of a consistent internal cue to a class of external stimuli, and the combination of two or more Rs responses into a larger Rs response, follow the type of laws set forth in the above definition of differential learning which are similar in principle to Pavlovian laws of contiguity, and Denny's Elicitation theory (1956, 1960). This phase of learning is analogous to the trace formation stage suggested by Melton (1963a).

III. The second stage of encoding, i.e., the firing of a response aggregate (R_m) associated with an Rs response, follows the postulates given in the R_m definition above. The response aggregate functions similarly to Sperling's recognition buffer (1966) providing simultaneous elicitation of a complex of central responses. The elicitation of the aggregate constitutes a conditioning trial. The nature of the interference and/or transfer which occurs will depend upon associative connections in the R_m aggregates involved. This is analogous to the trace storage phase of Melton (1963), and it is in agreement with Osgood's theoretical model of storage (1953).

V. Decoding, i.e., the activation of $Rs_I \rightarrow Rs$ (see retrieval model), follows the same laws of differential learning described in II above. An information search, involving the $Rs \rightarrow rm \rightarrow Rm \rightarrow Rs_I$ chain, will follow the laws of interference based on overlap of associative structures. (An information search is necessary if the Rs_I cue is not available.) This is analogous to trace retrieval, as in Melton (1963).

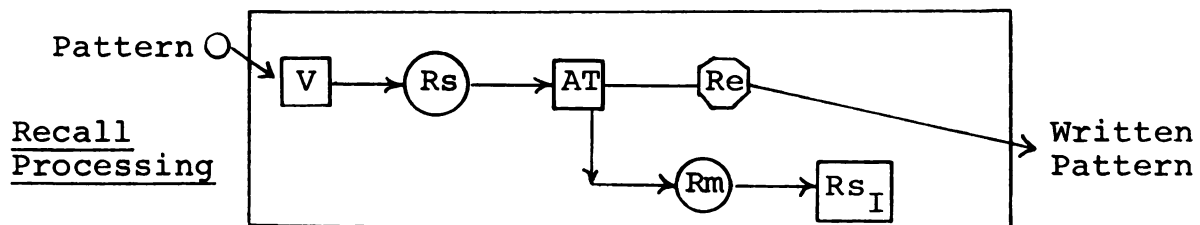
In summary of III, IV, and V trace formation is affected only by laws of contiguity and generalization, while storage is affected by laws of associative transfer and interference. Retrieval may be affected by both kinds of learning, depending upon the availability of the Rs_I cue. (This is consistent with Broadbent's (1963) findings that similarity of items in an STM paradigm does not produce the interference effects which this similarity would produce in an LTM paradigm. In other words, short-term retrieval does not require storage or decoding activity, and hence, is not affected by the interference effects which long-term retrieval demonstrates. This is also consistent with Bower's (1967) concept of "primary encoding" of stimulus attributes, and "secondary encoding" of the attributes with their context to produce meaning.)

MODEL

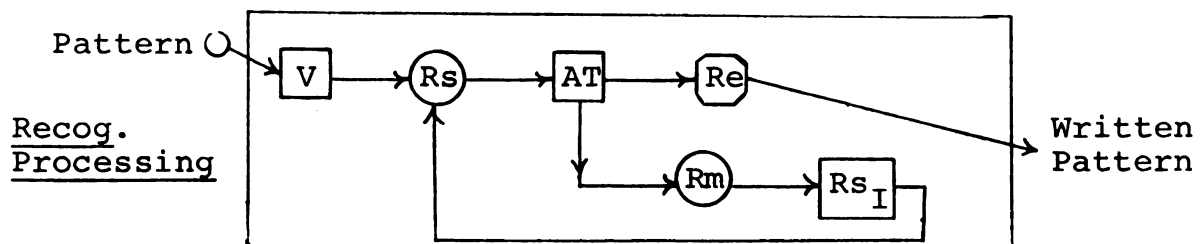
Part I. Conditioning paradigm--ENCODING (Trace formation, trace storage)

Since the learning, or acquisition situation involves the presentation of information which will affect Ss behavior at a later time, the important theoretical events analyzed here are trace formation, i.e., structural change, and trace storage.

Recall--A response analysis of the processing of information in a learning situation in which the information is to be recalled.

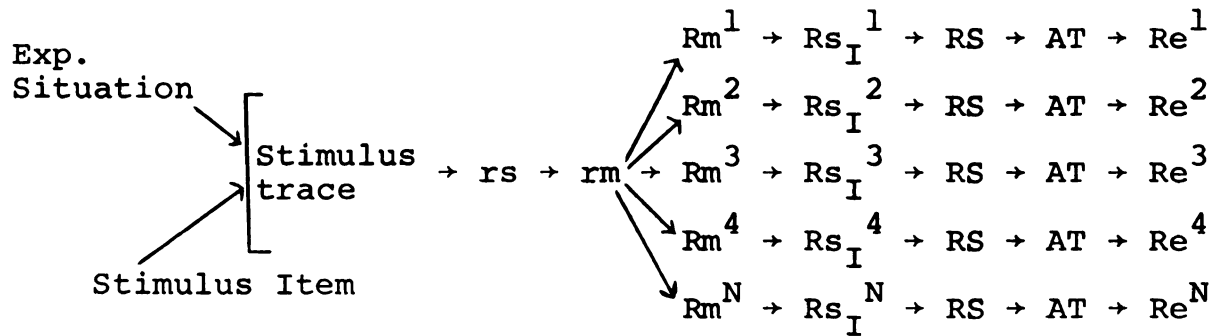


Recognition--A response analysis of the processing of information in a learning situation in which the information is to be recognized.

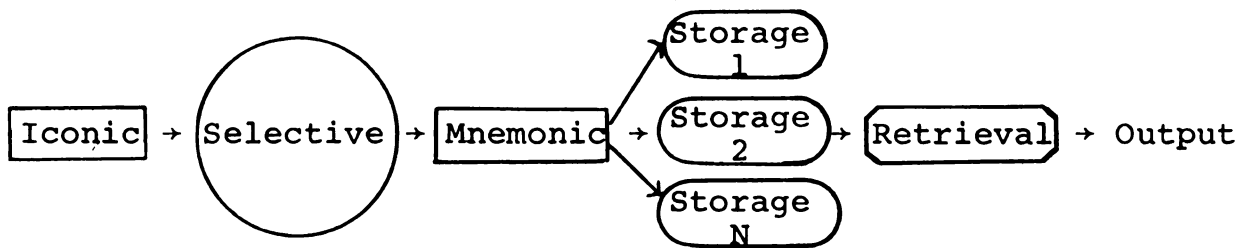


Part II. Memory test--DECODING, RETRIEVAL (Since the memory test involves the activation of structural traces, the important theoretical events analyzed here are trace storage and trace retrieval.)

Recall--Response analysis of processing during a recall test of memory.



Response Analysis



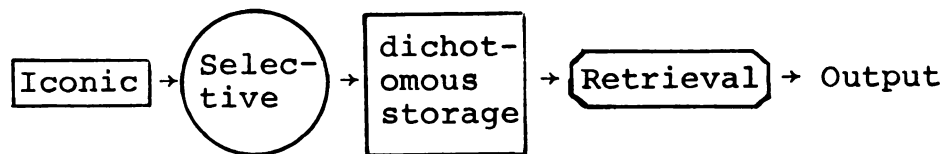
Theoretical Processing Mechanism

Recognition--A response analysis of processing during a recognition test of memory.

Experimental
Situation

Specific items on list → [Stim. trace → R_s → R_{m_d} → R_{s_I} → R_S → A_T → R_e]

Response Analysis



Theoretical Processing Mechanism

Memory: DECODING, RETRIEVAL

Recall instructions (for both acquisition groups) "Write all the items that you remember from yesterday's list." Exp. situation and motivational cues rs rm Rm Rs_I

Recall → what is it? → (what kind of building item?)

(a tool, you → nail
hit it, it holds things together)

Recog. → is it correct? → is correct → yes, it is correct

Since Rm-Rs_I association is indistinct with the recognition processing style, the probability of a particular Rs_I being fired is a function of habit strength of the particular Rm-Rs_I association with earlier items having the advantage. The likelihood of retrieving an item is low with the recognition acquisition processing.

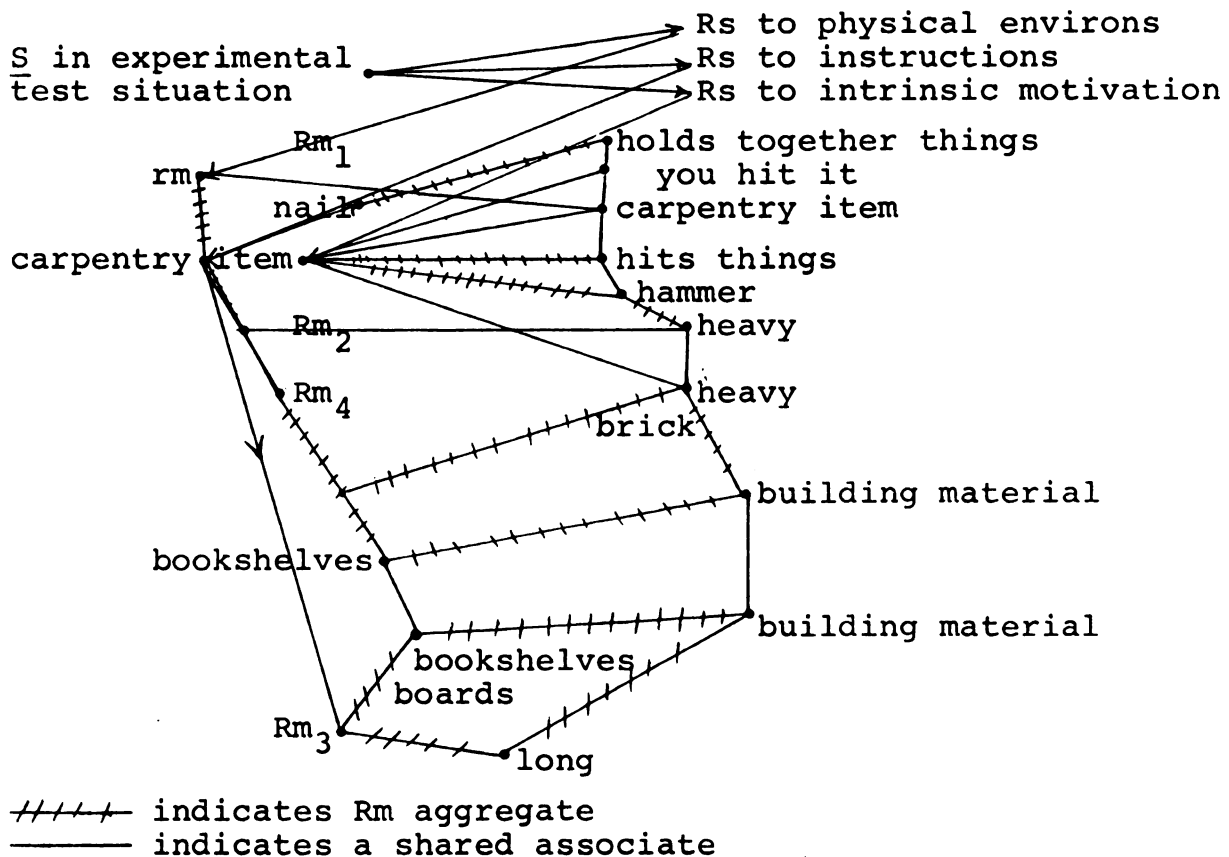


Figure 1A. Theoretical associative structure of S who learned under recall demand situation. (R_M, shares one associate with Rm carpentry item; Rm shares one associate with Rm heavy; Rm₃ shares 2 associates with Rm₄; therefore, other things being equal, Rm₄ is most likely to be fired on an information search in the experimental situation.)



APPENDIX B

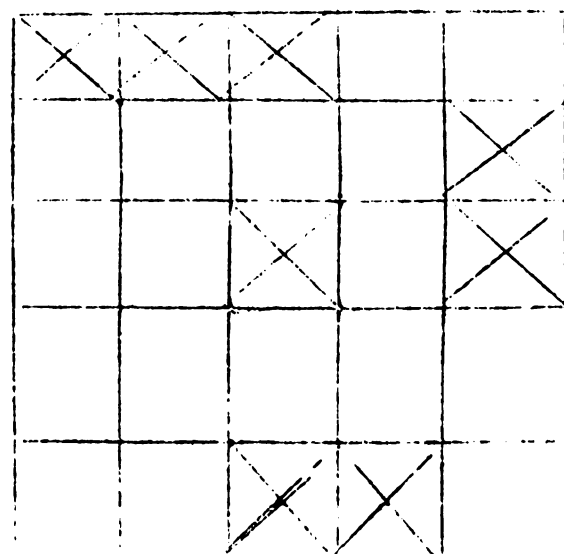
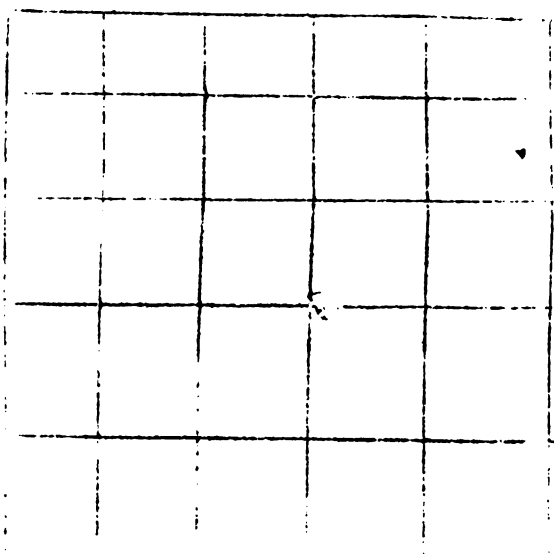
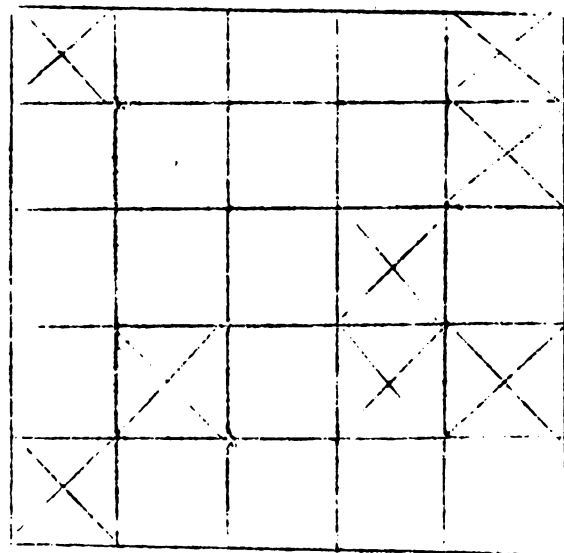
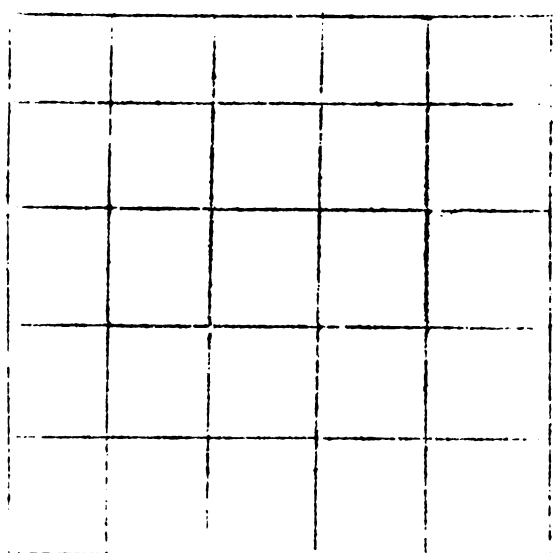
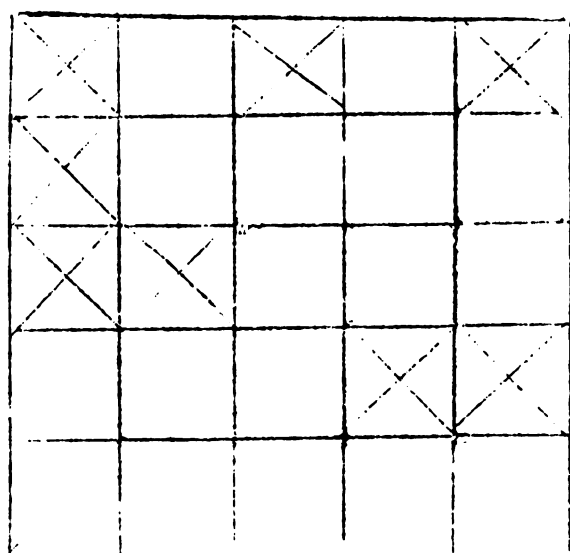
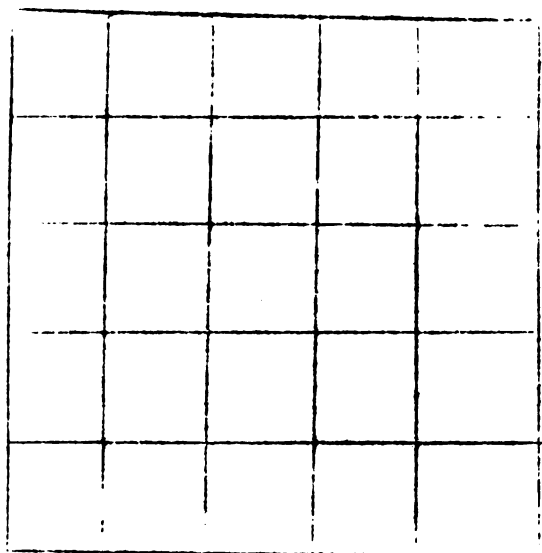
MATERIALS

Sample Data Sheet

RECALL

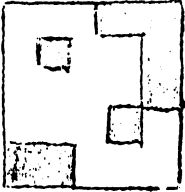
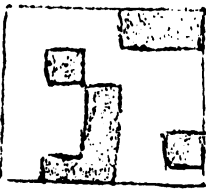
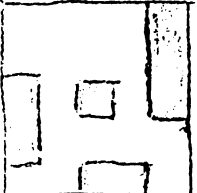
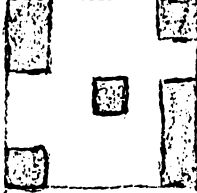
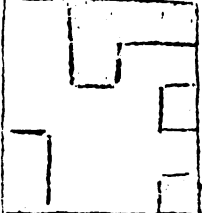
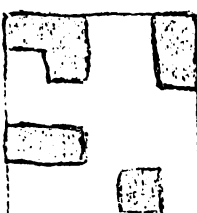
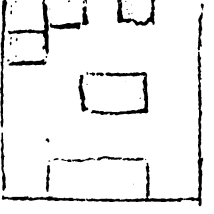
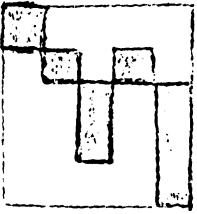
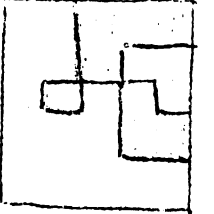
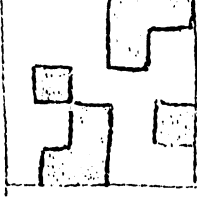
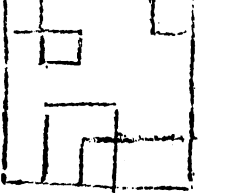
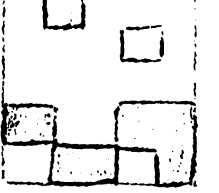
RECOGNITION

Seq.
Des.
Name
Date



1 2 3

PATTERNS

CORRECT	INCORRECT (DUMMY*)
1) 	2) 
3) 	4) 
5) 	6) 
7) 	8) 
9) 	10) 
11) 	12) 

*The pattern which is the incorrect alternative on a recognition test trial is the "dummy" pattern (or familiarization control) on a recall test trial.



APPENDIX C

ADDITIONAL STATISTICAL INFORMATION

TABLE 1Ca
Accuracy Scores for Second and Fourth Reproductions of Each Pattern
Under Pre/Post-Stimulus Instructions, Using the Original
Pattern as the Scoring Standard

	Repro- duction	1	7	9	3	5	11
<u>Pre</u>	Accuracy 2	2.512	2.403	2.435	2.500	2.581	2.031
	4	2.570	2.482	2.554	2.675	2.623	2.559
<u>Post</u>	Accuracy 2	2.492	2.413	2.471	2.584	2.546	2.108
	4	2.474	2.398	2.458	2.662	2.579	2.348

AOV TABLE 1CaS

(Separate Analysis for Each Pattern)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 1				
Total	5.57698	97		
Between (LS)	3.60802	48		
A	0.08213	1	0.08213	1.09473
Error B	3.52590	47	0.07502	
Within (LS)	2.00227	49		
E	0.00978	1	0.00978	0.23484
AE	0.03578	1	0.03578	0.85915
Error W	1.95745	47	0.04165	
Pattern 7				
Total	9.08368	99		
Between (LS)	5.60994	49		
A	0.03460	1	0.03460	0.29785
Error B	5.57534	48	0.11615	
Within (LS)	3.47644	50		
E	0.02605	1	0.02605	0.36835
AE	0.05579	1	0.05579	0.78888
Error W	3.39460	48	0.07072	
Pattern 9				
Total	8.84369	99		
Between (LS)	6.43988	49		
A	0.02268	1	0.02268	0.16965
Error B	6.41720	48	0.13369	
Within (LS)	2.40381	50		
E	0.07054	1	0.07054	1.52226 ns
AE	0.10890	1	0.10890	2.34997 ns
Error W	2.22437	48	0.04634	
Pattern 3				
Total	6.37977	89		
Between (LS)	4.29527	44		
A	0.02768	1	0.02768	0.27892
Error B	4.26759	43	0.09925	
Within (LS)	1.96561	45		
E	0.35977	1	0.35977	10.00020 ^b
AE	0.05256	1	0.05256	1.46102
Error W	1.54696	43	0.03598	

AOV TABLE 1CaS (cont.)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 5				
Total	4.61405	95		
Between (LS)	2.42879	47		
A	0.03764	1	0.03764	0.72418
Error B	2.39115	46	2.05198	
Within (LS)	2.18526	48		
E	0.03447	1	0.03447	0.73735
AE	0.00059	1	0.00059	0.01252
Error W	2.15021	46	0.04674	
Pattern 11				
Total	5.24424	91		
Between (LS)	3.15386	45		
A	0.39209	1	0.39209	6.24672 ^a
Error B	2.76177	44	0.06277	
Within (LS)	2.34254	46		
E	0.26335	1	0.26335	5.94054 ^a
AE	0.15587	1	0.14487	3.26791 ^c
Error W	1.95057	44	0.04433	

Factor A--Instructions

Factor E--Score on Trial 2, 4

a < .05

b < .01

c < .10

TABLE 1Cb

Accuracy Score for Fourth Reproduction of Each Pattern, Under
Pre/Post-Stimulus Instructions, Using the Second
Reproduction and the Original Pattern (Indicated
as 2 and 0 in the Table) as Scoring Standards

Scoring Standard		1	7	9	3	5	11	
Pre	Accuracy	2	2.585	2.672	2.531	2.493	2.405	2.031
		0	2.570	2.482	2.554	2.675	2.623	2.559

Post	Accuracy	2	2.521	2.550	2.368	2.485	2.400	2.108
		0	2.472	2.400	2.458	2.662	2.579	2.348



AOV TABLE 1CbS

(Separate Analysis for Each Pattern)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 1				
Total	11.27978	97		
Between (LS)	7.60436	48		
A	0.15564	1	0.15564	0.98208
Error B	7.44872	47	0.15848	
Within (LS)	3.81711	49		
E	0.02321	1	0.02321	0.28811
AE	0.00660	1	0.00660	0.08188
Error W	3.78679	47	0.08057	
Pattern 7				
Total	13.49113	99		
Between (LS)	6.43149	49		
A	0.26533	1	0.26533	2.09605 ns
Error B	6.07606	48	0.12658	
Within (LS)	7.14974	50		
E	0.73154	1	0.73154	5.47834 ^a
AE	0.00863	1	0.00863	0.06463
Error W	6.40958	48	0.13353	
Pattern 9				
Total	15.72793	99		
Between (LS)	8.29512	49		
A	0.42081	1	0.42081	2.56517 ns
Error B	7.87431	48	0.16405	
Within (LS)	7.43281	50		
E	0.07992	1	0.07992	0.52373
AE	0.02826	1	0.02826	0.18518
Error W	7.32463	48	0.15260	
Pattern 3				
Total	16.53046	89		
Between (LS)	9.80061	44		
A	0.00240	1	0.00240	0.01055
Error B	9.79821	43	0.22787	
Within (LS)	6.38094	45		
E	0.72542	1	0.72542	5.51655
AE	0.00010	1	0.00019	0.00146
Error W	5.65444	43	0.13150	

AOV TABLE 1CbS (cont.)

Source of Variance	Sum of Squares	DF	Mean Square	F Ratio
Pattern 5				
Total	9.98852	95		
Between (LS)	6.41013	47		
A	0.01508	1	0.01508	0.10844
Error B	6.39505	46	0.13902	
Within (LS)	3.57839	48		
E	0.94903	1	0.94903	16.66076 ^b
AE	0.00911	1	0.00911	0.15987
Error W	2.62026	46	0.05696	
Pattern 11				
Total	23.88023	91		
Between (LS)	11.93669	45		
A	0.10157	1	0.10157	0.37760
Error B	11.82513	44	0.26898	
Within (LS)	11.65563	46		
E	3.38708	1	3.38708	18.86932
AE	0.47348	1	0.47348	2.63772
Error W	7.89809	44	0.17950	

Factor A--Instruction (pre/post)

Factor E--Score on trial 4 with Second Reproduction,
Original Pattern, as Scoring Standard

a < .05

b < .001

TABLE 2C

2x2x2 Analysis of Variance for Mean Accuracy Scores for
2nd and 4th Reproductions when Conducted for Each
Pattern.

[Factor A was Instructions (Pre-Post), Factor B
did or did not recall after 24-hours, and Factor
E was a comparison of scores on trials 2 and 4.
Only significant or near significant F values
involving Factor B are given (see Figure 1-C for
means).]

Pattern 7	Accuracy	ABE - $F = 7.551$, $p < .05$
Pattern 9	Accuracy	AB - $F = 4.4957$, $p < .05$
Pattern 5	Accuracy	AB - $F = 3.259$ - n.s.

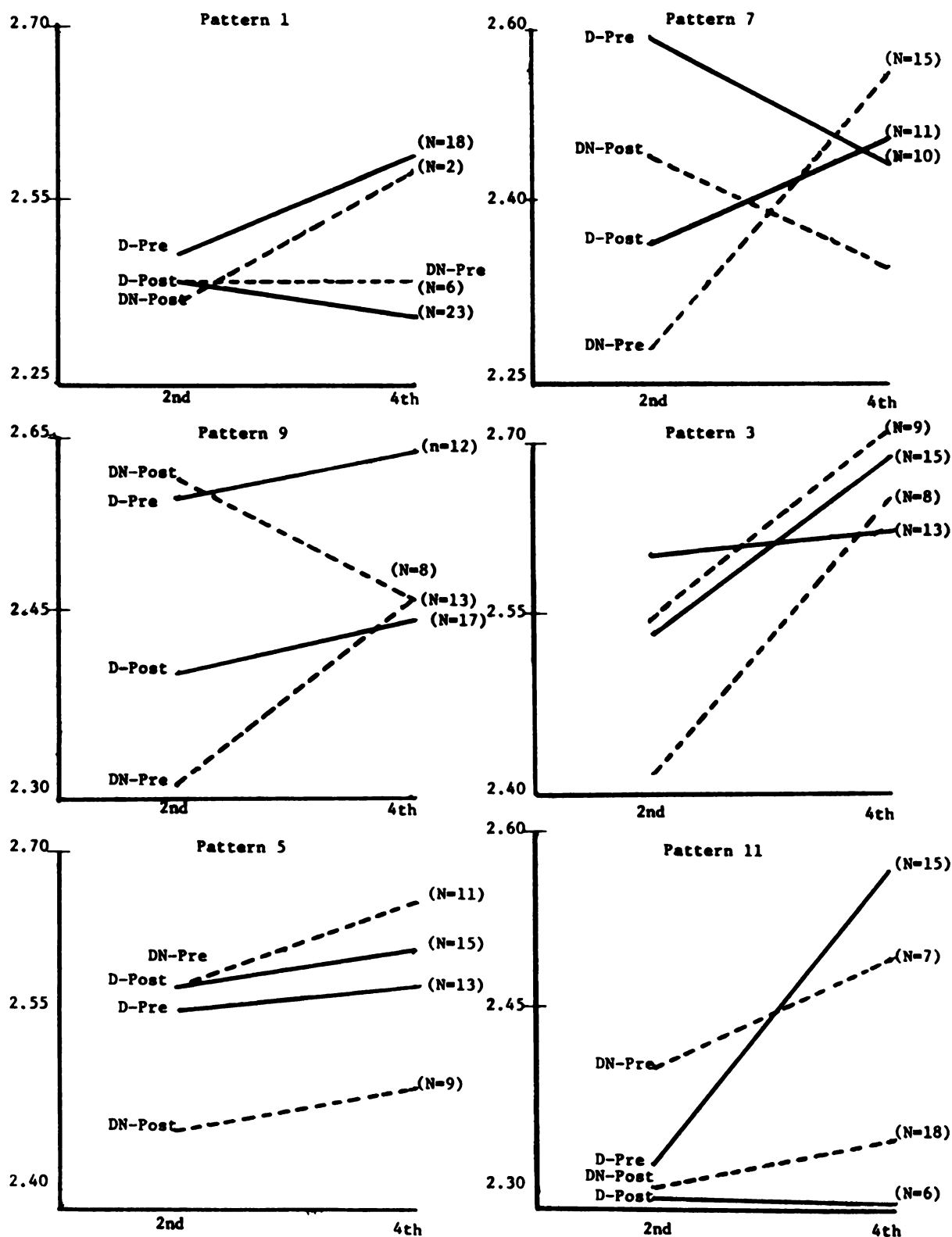


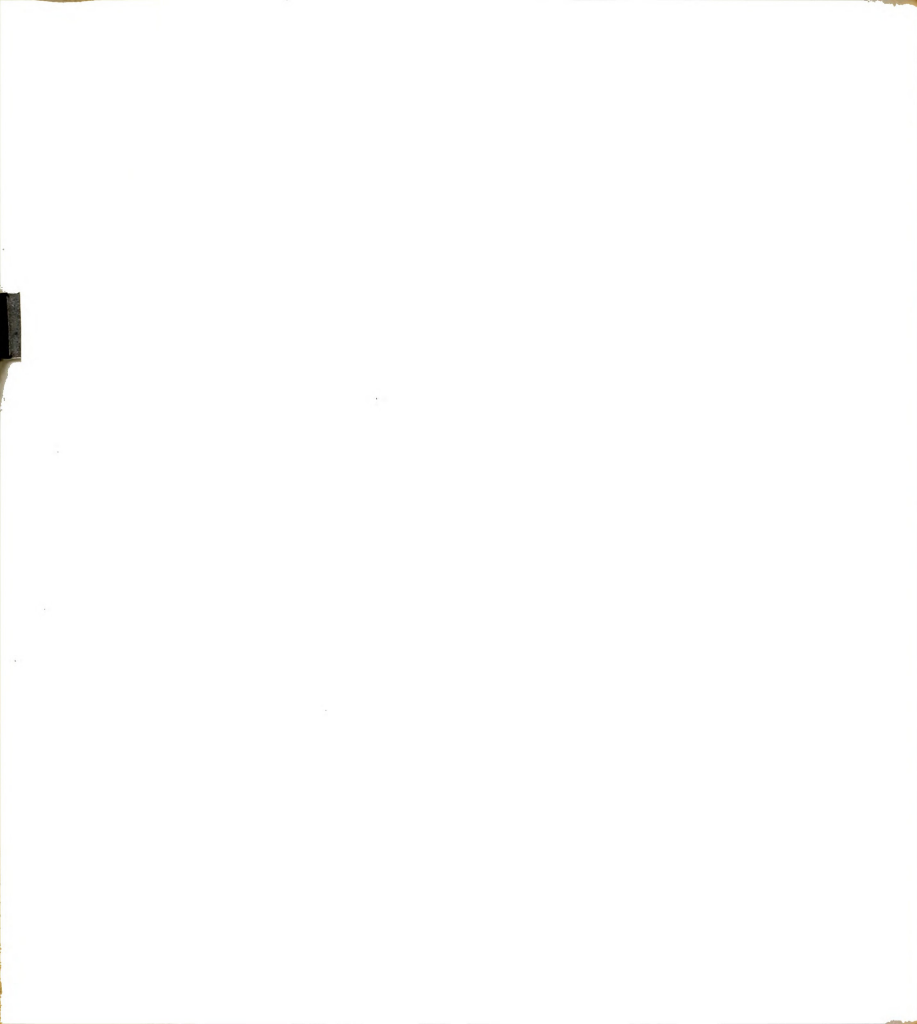
Figure 1C. Mean accuracy scores on 2nd and 4th reproductions, using the original pattern as scoring standards for patterns which were reproduced at 24 hours (D) and patterns which were not reproduced at 24 hours (DN).

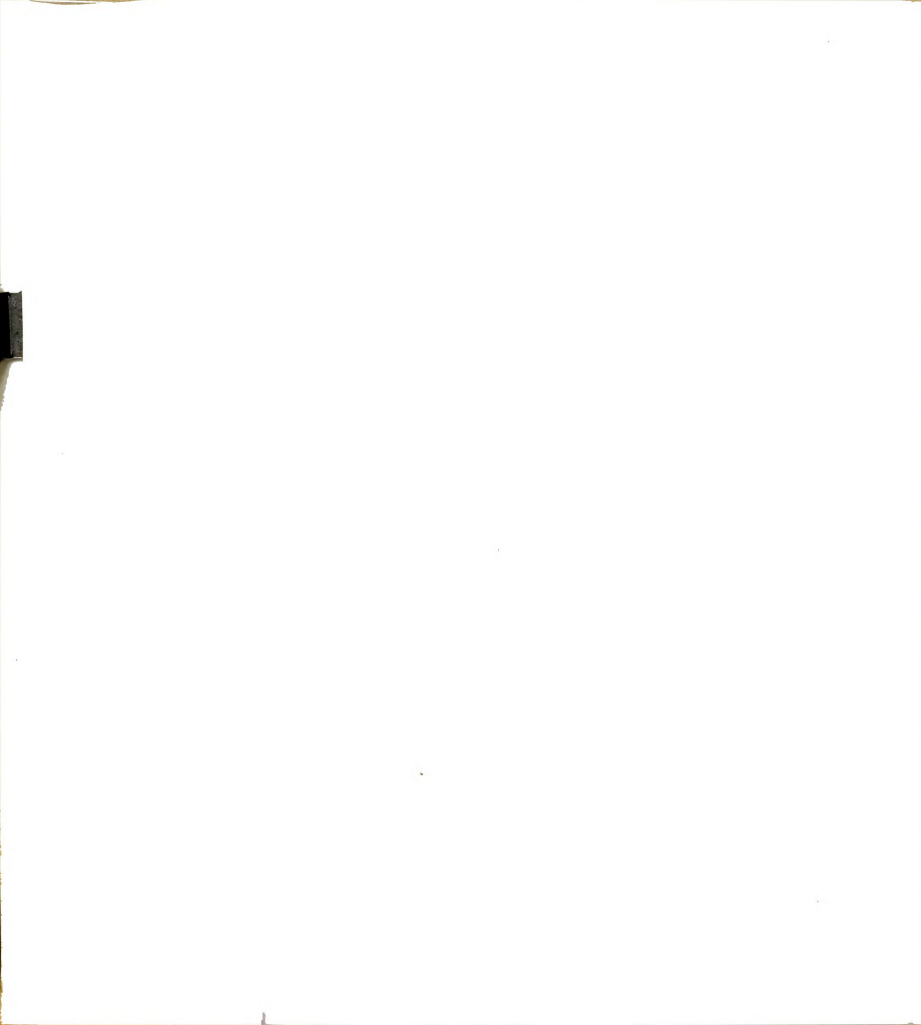
TABLE 3C

Percentage of Set 1 and Set 2 Patterns Which
Were Recognized Following Recall and
Non-Recall the 24-Hour Test

	Recalled on the 24-Hour Test	Not Recalled on the 24-Hour Test
Set 1 Patterns	84%	54%
Set 2 Patterns	66%	57%







MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03056 2650