AN EXPLORATORY STUDY OF THE DERIVATION AND RETENTION OF HIGHER-ORDER CODING SCHEMES DURING THE FORMATION OF VERBAL ASSOCIATIONS

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ABSTRACT

AN EXPLORATORY STUDY OF THE DERIVATION AND RETENTION OF HIGHER-ORDER CODING SCHEMES DURING THE FORMATION OF VERBAL ASSOCIATIONS

by Donald J. Freeman

Problem

Recent investigations have shown that the comparative ease with which a given S is able to form a set of associations is dependent upon the nature and quantity of the mediational links (encoding schemes) which he establishes between the stimulus and response terms (Underwood and Schulz, 1960; and Martin, Boersma, and Cox, 1965a). But these studies have focused on the perception of relations between the stimulus and response terms in each pair (first-order coding schemes). They have not determined whether or not Ss attempt to further condense the units of retention by looking for relations among the first-order coding schemes, i.e., by deriving higher-order coding schemes. Based on the assumption that Ss will form higher-order coding schemes, this dissertation attempted to answer three questions.

First, what is the impact of the derivation of higher-order coding schemes on short-term retention? Second, what is

the impact of higher-order coding schemes on long-term retention? Third, what role does perception play in the derivation of higher-order coding schemes?

Procedure

In the two experiments reported in this dissertation, Ss were presented with a list of nine triads, each consisting of three familiar terms (e.g., mammal-bare-dear). Their task was to form associations among the three terms in each triad in such a way that the presentation of any one of them during the test trial would elicit the other two terms as responses. Because each triad was constructed according to the same relationship, or principle, it was possible for a given S to derive a single relationship which would apply for all nine triads. Through use of this list, the problem of identifying Ss who had derived higher-order coding schemes was reduced to that of determining whether or not a given S had discovered the "built-in" principle. The first two questions were thus resolved by comparing the performance of Ss who discovered the principle with that of Ss who did not discover the principle.

The final question was approached through the use of lists with varying perceptual cues. Eight lists were constructed according to all possible combinations of the two conditions on each of the following variables:

(1) Degree of embeddedness of the underlying principle -

The principle underlying each triad was constructed according to one of the following two rules:

(a) two-homonym lists - "If two terms in each triad are transformed into their homonyms, they represent exemplars of the third, or categorical term."

(b) one-homonym lists - "If one term in each triad is transformed into its homonym, it and one other term represent exemplars of the third, or categorical term."

e.g., mammal-bare-dear vs. mammal-bear-dear

(2) Size of print -

The categorical term in each triad was either capitalized with the other two terms in small print (caps) or all three terms were printed in small letters (no caps).

e.g. MAMMAL-bare-dear vs. mammal-bare-dear

(3) Order of presentation -

The categorical term was either fixed in the first position across all nine triads (fixed), or it was varied in position from one triad to the next (random).

e.g., mammal-bare-dear   bare-mammal-dear
metal-steal-lead   steal-lead-metal

In an attempt to answer the third question, the per cent of Ss who discovered the principle as well as other general measures of performance were determined for each condition along the three variables.

In Experiment I, 218 college sophomores were presented with eight learning trials and eight test trials. A questionnaire (L.P.F.Q.) was administered at the completion of each experimental session to determine which Ss had derived higher-order coding schemes. Long-term retention was also determined by administering a single test trial three weeks after initial acquisition. The conditions in Experiment II were highly similar except that the 244 Ss in this experiment were presented with only one learning and one test trial.

Major Findings

The results of these two experiments provided partial answers to the above three questions. First, the short-term retention of those Ss who derived higher-order coding schemes in this task was clearly superior to the corresponding performance of Ss who derived different relations for each triad, i.e., a set of first-order coding schemes. Ss who discovered the principle not only formed the required associations more rapidly than those who did not, but they also made fewer intrusions in recall. Only the difference in number of intrusions made on the first test trial of Experiment II failed to reach a statistically significant level. These findings were explained in terms of a simple extension of Underwood's two stage model of associational learning (1962).

Second, the derivation of higher-order coding schemes during acquisition apparently has little or no impact on long-term retention. Differences between Ss who either did or did not discover the principle failed to reach statistical significance on any measure of long-term retention, including number of words correctly recalled and various types of intrusions. Although several explanations may be advanced for this unexpected finding, the author attributed these results to the fact that a sizable number of Ss who discovered the principle during acquisition were apparently unable to recall the principle on the retention trial. This loss in retention was, in turn, accounted for by a simple modification of interference theory.

Finally, the results of this study failed to yield any clear conclusions regarding the role of perception in the derivation of higher-order coding. Although differences between Ss presented one- and two-homonym lists were highly significant across all measures of short-term retention, the corresponding differences along the other two variables failed to ever reach statistical significance (alpha = .05). However, there was some evidence to suggest that capitalizing the categorical terms may have facilitated performance on one-homonym lists, while registering little impact on two-homonym lists.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES - Continued

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

STATEMENT OF THE PROBLEM

I. Statement of the Problem

Several recent investigations have shown that performance on associational tasks is improved when Ss interject some form of mediational link between the stimulus and response terms (Underwood and Schulz, 1963 a; Martin, Boersma, and Cox, 1965 a; and Cox, 1965). Several explanations might be advanced regarding the impact of this mediational activity. However, an approach which seems especially fruitful suggests that the critical function which these links serve is that of somehow uniting the two terms in each pair. Epstein, Rock, and Zuckerman (1960), for example, have shown that associations between pairs of nouns presented as meaningful units (e.g., CAKE near ROAD) are formed more rapidly than associations between the same two nouns presented in a non-unit form (e.g., CAKE and ROAD).

This view of the function of mediational links represents a direct application of Miller's (1956 a) analysis of human learning. Miller suggests that during any learning task, individuals actively attempt to transform incoming information into a small number of compact units of retention. When presented with the task of retaining the number series 2, 5, 8, 11, 14, 17, and 20, for example, most individuals perceive the underlying relationship--each number differs from the preceding number by three. By transforming the number series into a sentence which describes this relationship, the task of retaining the complete series is reduced from that of retaining seven independent numbers to the task of retaining a single sentence. In an analogous fashion, the formation of mediational links between each stimulus and response term in an associational task may reduce the number of units of information with which an individual must effectively deal.

Miller further argues that an individual is forced to make these transformations because the human storage system can only absorb a limited number of units or "chunks of information" at any one point in time.

> It is as if each storage register could accept one of a tremendous variety of alternative symbols, but the number of registers available was quite limited. (Miller, 1956 a, p. 129.)

Therefore, Miller (1956 a) depicts the process of transforming information into more efficient units as analogous to carrying a purse which will hold only seven coins, irrespective of the monetary value of each. In the same way that an individual can carry more money if the coins are silver dollars, instead of pennies, an individual can retain more information if he stores efficient units of recall, rather than informationally poor units.

Bruner (1959) appears to be in complete agreement with Miller. At one point he states . . .

> One of the most notable things about the human mind is its limited capacity for dealing at any one moment with diverse arrays of information. . . . The seven things we deal with must be worth their weight. (Bruner, 1959, p. 77.)

The overall process of transforming incoming information into a smaller number of efficient units of retention shall be referred to as the <u>encoding process</u> throughout this dissertation. Other authors have used the terms "recoding" (Miller, 1956 a) and "decoding" (Osgood, 1953) to depict the same phenomenon. The particular form which a given transformation takes shall be referred to as either a <u>coding scheme</u> or an <u>encoding scheme</u> (e.g., naming and describing each figure as it is presented while attempting to retain a series of figures; a statement of the relationship in the above number series, etc.)[1] These terms have been adopted in preference to the terms "mediation" and "verbalization" because the latter have a very general reference. Coding schemes, on the other hand, refer only to an attempt on the part of the individual to reduce the number of units of retention.

The process of encoding or storing information represents only one phase of the learning process. Once information has been encoded or stored, the task of drawing this information out of storage still confronts the individual. This process

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[1]The terms "coding scheme" and "encoding scheme" are used interchangeably throughout this dissertation.

of regenerating the stored information will be referred to as the decoding process throughout this dissertation. Decoding in associational learning corresponds to the S's attempts to generate the appropriate response term as each stimulus is presented.

Few would question the assertion that encoding and decoding are interrelated processes. It therefore seems reasonable to suggest that the nature of the coding schemes which are derived during encoding will have a significant impact on both the nature and extent of decoding. A S who discovers the relationship among the numbers in the above series, for example, should be able to recall more digits during decoding than a S who does not discover this relationship. And, as noted in the introductory statement, associations are formed more rapidly between pairs of terms which are linked by some form of coding scheme than between pairs for which no mediational link has been established (Underwood and Schulz, 1960; Martin et al., 1965 a; and Cox, 1965).

However, several questions regarding the nature of encoding and decoding during the formation of verbal associations have not been answered by empirical research. The following example should provide the necessary background for a discussion of some of these issues.

Imagine that three individuals are asked to serve as subjects in a paired-associates task involving the following three pairs of familiar terms:

tree - wood
mirror - reflection
river - water

Further imagine that the encoding schemes adopted by these three individuals take the following form:

Individual no. 1: transforms the two words in each pair into a compact unit by forming a sentence which links the two words together; namely . . .

"WOOD comes from TREES."
"I see my REFLECTION in a MIRROR."
"The WATER in the RIVER is cold."

Individual no. 2: initially derives sentences of this type, but then discovers that the sentences he has derived may, in turn, be organized into a short story or theme; namely . . .

"When I look at my REFLECTION in the MIRROR, it reminds me of staring into the clear WATER of a RIVER. The experience is as refreshing as chopping WOOD in a grove of TREES."

Individual no. 3: discovers the functional relationship between the first pair of terms; i.e., "WOOD comes from TREES." He then examines each succeeding pair on the list to determine whether or not they fit this same relationship. Since REFLECTIONS do come from MIRRORS and WATER does come from RIVERS, this search results in the discovery of a single relationship which will hold for all three pairs of terms; namely . . .

"(<u>A given response term</u>) comes from (<u>The relevant stimulus term</u>.)"

It should be apparent from this example that even in comparatively simple associational tasks, diverse forms of encoding may occur. Individual one, for example, has derived three independent coding schemes, each of which unites a sing

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single pair of stimulus and response terms. Coding schemes of this type which are based on relationships between only one set of stimulus and response terms will be referred to as <u>first-order coding schemes</u> throughout this dissertation.

Individuals two and three, on the other hand, have reduced the number of coding schemes to one--a theme and a general relationship, respectively. Coding schemes of this type which are based on relationships between two or more first-order coding schemes, and which effectively reduce the number of units which the S must recall, will be referred to as <u>higher-order coding schemes</u> throughout this dissertation.

This illustration gives rise to a basic assumption of this dissertation; namely, when individuals are presented with a learning task involving the formation of verbal associations, a significant proportion of these Ss will attempt to formulate higher-order coding schemes. The following set of questions, which are based on this assumption, therefore, serve as the focus of this investigation. Given that a group of individuals has been presented with a task which involves the formation of verbal associations . . .

(1) What effect, if any, does the derivation of higher-order coding schemes have on short-term retention?

(2) What effect, if any, does the derivation of higher-order coding schemes have on long-term retention?

(3) Does an individual's overall perception of the stimulus and response terms affect the probability that he will derive a higher-order coding scheme?

Since available literature fails to provide an answer to the more fundamental question of whether or not Ss will attempt to formulate higher-order coding schemes during associational tasks, there is little or no direct basis for predicting an answer to any of these specific questions. This is not to say, however, that no other authors have referred to the basic question of whether or not Ss will attempt to formulate higher-order coding schemes.

The following statement by Underwood and Schulz (1960), for example, raises the question of whether or not Ss will attempt to utilize the same relationship for more than one pair of terms (similar to individual no. 3 in the above illustration). Commenting on the verbal reports of a group of Ss who had just completed a paired associate task involving pairs of nonsense trigrams and familiar three-letter words, these authors state . . .

> Another fact we have not tried to express numerically, appears quite universally in the subjects' reports. This is the fact that a subject will use several types of mediators in learning the list. <u>It is possible that the subject tried to use a consistent mediation and failed</u>; all we know is that at the end of learning the associations are quite varied in type.[2] (Underwood and Schulz, 1960, p. 300.)

Although Battig (1966) does not argue that Ss will attempt to use the same mediator for more than one pair of terms, he does argue that Ss do not learn each pair independently. Commenting on an experiment in which Ss learned

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[2]Underlining has been added by this author.

pairs of nonsense shapes and two-digit numbers, he states . . .

> . . . we were both surprised and impressed by the frequency of reports indicating some sort of interrelating or grouping of two or more pairs together, instead of each pair being learned as a separate individual entity. (Battig, 1966, p. 178.)

As a result of these observations, Battig undertook a series of experiments which demonstrated that under experimental conditions which favored the formation of inter-pair groups according to similarities in degree of learning, fewer errors were made than under conditions which did not favor such grouping. For example, when pairs were presented in the same serial position until responded to correctly and then varied in position from trial to trial, fewer errors were made than when the position of every pair was changed on each trial. Battig attributed these findings to the Ss' use of a form of "subjective organization" whereby the number of units of retention were reduced. At one point in the discussion he states . . .

> Since it is the rare paired-associate list in which the number of pairs does not exceed the 'magical number seven', it is highly unlikely that the S could simultaneously carry each individual pair in the form of a separate bit of information. Consequently, some form of grouping or recoding into higher-order multiple-pair chunks may be a necessary prerequisite to successful performance on paired-associate tasks. (Battig, 1966, p. 181.)

Thus, Battig not only argues that S's form higher-order coding schemes, but he also maintains that the use of these schemes facilitates performance on paired-associate tasks. However, one may question whether the S's initial attempts to form interrelationships among more than one pair of terms will be based on similarities in item difficulty or degree of learning. It seems more reasonable to suggest that such bases will be adopted only under those conditions in which more efficient approaches have failed (e.g., deriving the same relationship among the terms in more than one pair). Furthermore, Battig's evidence for the facilitating effect of higher-order coding schemes is somewhat questionable. Other differences exist between the experimental and control conditions which may also favor the experimental group (e.g., presence or absence of position cues). In short, Battig's study points to the need for further research regarding the role of higher-order coding schemes in associational learning.

Other authors have also suggested that Ss may attempt to form themes during associational tasks (similar to individual no. 2 in the preceding illustration). Miller, Gallanter, and Pribram (1960), for example, maintain that individuals faced with a paired-associates task begin their transformations by forming words from the dominant aspects of nonsense syllables. These words are then organized into sentences which, in turn, are organized into themes. Of major importance, however, is the fact that these authors rely on logical, rather than empirical, support for their assertions.

In short, at least three other authors have made some reference to the basic question of whether or not Ss will attempt to formulate higher-order coding schemes during an associational task. But, with the possible exception of Battig (1966), none of these authors have successfully treated this question as the subject of an empirical investigation.

One problem which may have curtailed attempts to answer this question empirically is that of finding a suitable method for studying the derivation of higher-order coding schemes. An investigation which involves the collection of verbal reports, for example, must overcome several problems which stem from the idiosyncratic nature of the higher-order coding schemes which individuals may adopt. The technique of presenting Ss with some form of higher-order coding scheme immediately prior to the first learning trial is also somewhat inappropriate in that it never really answers the question of whether or not Ss would have developed such schemes on their own. In short, the two methods which have been adopted in other investigations of encoding during associational learning do not lend themselves to an initial study of higher-order coding schemes.

Fortunately, however, an answer to this methodological problem is suggested in the literature; namely, the technique of building some a priori structure into the list of stimulus materials. This technique has proved especially fruitful in studies of encoding involving the free recall of serial lists (examples include Miller and Selfridge, 1950; Bousfield, 1953; Epstein, 1961; Underwood and Keppel, 1963; and Lindley, 1963). But it has rarely, if ever, been applied to studies of associative learning.

In this investigation, nine triads of familiar terms were constructed according to the same relationship or principle; namely, when two of the terms in each triad are transformed into their homonyms, they represent exemplars of the third or categorical term (e.g., bare-dear-mammal).[3] During the learning, or encoding trials, each S attempted to form associations among all three terms. During the decoding, or test trials, one term from each triad was presented, and Ss attempted to write the other two terms.

Because each triad was constructed according to the same principle, any S who attempted to look for common relationships among the terms in more than one triad should ultimately have discovered the "built-in" principle. Identification of Ss who have derived higher-order coding schemes was, therefore, reduced to the problem of determining whether or not a given S had discovered this consistent relationship. A questionnaire which was administered soon after the completion of the task was used in making these identifications.[4]

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[3]Lists were also constructed in which only one term was written as a homonym (e.g., bear-dear-mammal). These two lists, known as two-homonym and one-homonym lists, respectively, are presented in Table 1 in Chapter III.

[4]This questionnaire, known as the Level of Principle-Formation Questionnaire (L.P.F.Q.), was actually designed to identify Ss at four different levels ranging from Ss who formulated no first-order coding schemes to Ss who derived a single higher-order coding scheme for all nine triads; i.e.,

This resolution of the methodological problem cleared the way for an attempt to answer the three specific questions posed above. The following statement of the hypotheses suggests how these answers were derived.

II. Statement of the Hypotheses

The following hypotheses are based on the three questions which were stated in the preceding section of this chapter.[5]

A. The Derivation of higher-order coding schemes facilitates acquisition or short-term retention:

Hypothesis 1: (When level of principle formation is determined soon after the S reaches criterion or after the eighth test trial if he fails to reach criterion.) The mean level of performance over all eight test trials will be greater for those individuals at the higher levels of principle formation than for those at the lower levels.

Corollary 1a: The mean number of trials to criterion will be lower for Ss at the higher levels of principle formation than for Ss at the lower levels of principle formation.

Corollary 1b: The mean number of words recalled over all eight test trials will be greater for Ss at the higher levels of principle formation than for Ss at the lower levels of principle formation.

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discovered the principle. Since these four levels might be said to correspond to the process of discovering a common relationship or principle, they will be referred to as levels or principle formation throughout this dissertation.

[5]Many of the hypotheses refer to "levels of principle formation." These levels refer to successive steps in the discovery of the "built-in" principle, ranging from the formulation of no first-order coding schemes to the discovery and utilization of a single higher-order coding scheme; i.e., the principle. For a more complete description, see Table 2 in Chapter III.

Hypothesis 2:[6] With one exception, Ss at the higher levels of principle formation will make fewer intrusions in recall over all eight test trials than Ss at the lower levels. The single exception is number of improper plurals where the opposite prediction is made.

> Corollary 2a: The mean number of spelling distortions made by Ss at the higher levels of principle formation will be lower than the corresponding mean for Ss at the lower levels of principle formation.
>
> Corollary 2b: The mean number of extra-list intrusions made by Ss at the higher levels of principle formation will be lower than the corresponding mean for Ss at the lower levels of principle formation.
>
> Corollary 2c: The mean number of intra-list intrusions made by Ss at the higher levels of principle formation will be lower than the corresponding mean for Ss at the lower levels of principle formation.
>
> Corollary 2d: The mean number of improper plurals formed by Ss at the higher levels of principle formation will be greater than the corresponding mean for Ss at the lower levels of principle formation.
>
> Corollary 2e: The mean total number of intrusions made by Ss at the higher levels of principle formation will be lower than the corresponding mean for Ss at the lower levels of principle formation.

Hypothesis 3: (When level of principle formation is determined soon after the first test trial.) The mean number of words recalled on the first test trial by Ss at the higher levels of principle formation will be greater than the corresponding mean for Ss at the lower levels of principle formation.

Hypothesis 4: With one exception, Ss who derive higher levels of principle formation during the first learning trial will make fewer intrusions in recall on the first test trial than Ss at the lower levels. The single exception is the number of improper plurals where the opposite prediction is made. (If scores on the first

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[6]Hypotheses involving the number of intrusions made by Ss (Hypotheses 2, 4, 9, and 12) were not included in the proposal on which this dissertation is based. However, these hypotheses were formulated prior to the derivation of scores on these variables and are therefore not post hoc in nature.

test trial of Experiment II are interchanged with scores over all eight test trials of Experiment I, the five corollaries of hypothesis four are identical to those of hypothesis two. For purposes of convenience, therefore, these corollaries will not be repeated here.)

B. A Ss overall perception of the stimulus and response terms will affect the likelihood that he will derive a higher-order coding scheme:

Hypothesis 5: (When level of principle formation is determined soon after the first test trial.) Those Ss who are assigned lists with positive perceptual cues will have educed higher levels of principle formation during the first learning trial than those assigned lists which lack these cues.

Corollary 5a: At the end of the first test trial, the median level of principle formation will be greater for Ss presented lists with one homonym than for Ss presented lists with two homonyms.

Corollary 5b: At the end of the first test trial, the median level of principle formation will be greater for Ss presented lists in which the categorical terms are capitalized than for Ss presented lists in which the categorical terms are not capitalized.

Corollary 5c: At the end of the first test trial, the median level of principle formation will be greater for Ss presented lists in which the categorical term is always fixed in the first position than for Ss presented lists in which the categorical term varies in position from triad to triad.

Hypothesis 6: (When level of principle formation is determined soon after the subject reaches criterion or at the end of the eighth test trial if he fails to reach criterion.) Those Ss who are assigned lists with positive perceptual cues will have educed higher levels of principle formation during the eight learning trials than Ss assigned lists which lack these cues.

Corollary 6a: At the completion of the task, the median level of principle formation will be greater for Ss presented lists with one homonym than for Ss presented lists with two homonyms.

Corollary 6b: At the completion of the task, the median level of principle formation will be greater for Ss presented lists in which the categorical terms are capitalized than for Ss presented lists in which the categorical terms are not capitalized.

Corollary 6c: At the completion of the task, the median level of principle formation will be greater for individuals presented lists in which the categorical term is always fixed in the first position than for Ss presented lists in which the categorical term varies in position from triad to triad.

Hypothesis 7: Because of their effect on the derived level of principle formation, positive perceptual cues will aid in the formation of associations as early as the first learning trial.

Corollary 7a: The mean number of words correctly recalled on the first test trial by Ss presented lists with one homonym will be greater than the corresponding mean for Ss presented lists with two homonyms.

Corollary 7b: The mean number of words correctly recalled on the first test trial by Ss presented lists in which the categorical terms are capitalized will be greater than the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

Corollary 7c: The mean number of words correctly recalled on the first test trial by Ss presented lists in which the categorical terms are fixed in the first position will be greater than the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

Hypothesis 8: Because of their effect on the derived level of principle formation, lists containing positive perceptual cues will be learned more rapidly than lists which lack these cues.

Corollary 8a: The mean number of trials to criterion for Ss presented lists with one homonym will be less than the corresponding mean for Ss presented lists with two homonyms.

Corollary 8b: The mean number of trials to criterion for Ss presented lists in which the categorical terms are capitalized will be less than the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

<u>Corollary 8c</u>: The mean number of trials to criterion for Ss presented lists in which the categorical terms are capitalized will be less than the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

<u>Hypothesis 9</u>: Because of their effect on the derived level of principle formation, lists with positive perceptual cues will elicit fewer intrusions in recall than lists which lack these cues.

<u>Corollary 9a</u>: The mean total number of intrusions made by Ss presented lists with one homonym will be less than the corresponding mean for Ss presented lists with two homonyms.

<u>Corollary 9b</u>: The mean total number of intrusions made by Ss presented lists in which the categorical terms are capitalized will be less than the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

<u>Corollary 9c</u>: The mean total number of intrusions made by Ss presented lists in which the categorical term is fixed in the first position will be less than the corresponding mean for Ss presented lists in which the categorical term is not fixed in the first position.

<u>Hypothesis 10</u>: Because of their effect on the derived level of principle formation, positive perceptual cues will enhance the formation of verbal associations throughout the learning task.

<u>Corollary 10a</u>: The mean total number of words recalled over all eight test trials by Ss presented lists with one homonym will be greater than the corresponding mean for Ss presented lists with two homonyms.

<u>Corollary 10b</u>: The mean total number of words recalled over all eight test trials by Ss presented lists in which the categorical terms are capitalized will be greater than the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

<u>Corollary 10c</u>: The mean total number of words recalled over all eight test trials by Ss presented lists in which the categorical terms are fixed in the first position will be greater than the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

C. <u>The derivation of higher-order coding schemes during acquisition will result in higher levels of performance on the test for long-term retention</u>:

<u>Hypothesis 11</u>: The mean number of words correctly recalled on the test for long-term retention by Ss at the higher levels of principle formation during acquisition will be greater than the corresponding mean for Ss at the lower levels of principle formation.

<u>Hypothesis 12</u>: With one exception, the number of intrusions made on the test of long-term retention will be lower for Ss at the higher levels of principle formation than for Ss at the lower levels of principle formation. The single exception is number of improper plurals where the opposite prediction is made.

<u>Corollary 12a</u>: The mean number of spelling distortions made by Ss at the higher levels of principle formation will be less than the corresponding mean for Ss at the lower levels of principle formation.

<u>Corollary 12b</u>: The mean number of extra-list intrusions made by Ss at the higher levels of principle formation will be less than the corresponding mean for Ss at the lower levels of principle formation.

<u>Corollary 12c</u>: The mean number of intra-list intrusions made by Ss at the higher levels of principle formation will be less than the corresponding mean for Ss at the lower levels of principle formation.

<u>Corollary 12d</u>: The mean number of improper plurals formed by Ss at the higher levels of principle formation will be greater than the corresponding mean for Ss at the lower levels of principle formation.

<u>Corollary 12e</u>: The mean total number of intrusions formed by Ss at the higher levels of principle formation will be less than the corresponding mean for Ss at the lower levels of principle formation.

<u>Hypothesis 13</u>: Because of their effect on the derived levels of principle formation, positive perceptual cues will aid in long-term retention.

<u>Corollary 13a</u>: The mean number of words correctly recalled on the test of long-term retention by Ss presented lists with one homonym will be greater than the corresponding mean for Ss presented lists with two homonyms.

Corollary 13b: The mean number of words correctly recalled on the test of long-term retention by Ss presented lists in which the categorical terms are capitalized will be greater than the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

Corollary 13c: The mean number of words correctly recalled on the test of long-term retention by Ss presented lists in which the categorical terms are fixed in the first position will be greater than the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

Hypothesis 14: Among Ss who discover the principle during acquisition, the mean number of misspelled exemplar terms on the test of long-term retention made by Ss presented one-homonym lists will be greater than the corresponding mean for Ss presented two-homonym lists.

CHAPTER II

RELEVANT RESEARCH

I. General Overview of Chapter II

The function of this Chapter is to review that research which has some bearing on one or more of the three questions which were raised in the statement of the problem. Section II of this Chapter, for example, describes research which has been concerned with the role of encoding in paired associate learning. The purpose of section II is to provide a general background of the methods and issues which have characterized research in this area. Section III then reexamines each of the three questions in terms of relevant research. The purpose of section III is to provide evidence for the general predictions which were made in Chapter I.

II. The Use of Encoding Schemes in Paired-Associate Learning

Three comparatively independent approaches have been adopted in an attempt to study the use of encoding schemes in the formation of verbal associations--experimental establishment of a mediational chain via training on one or more lists; presentation of a single list, followed by verbal reports;

and, presentation of some form of encoding scheme as a part of the basic instructions.

The paradigm which underlies the majority of studies based on the first approach is to require Ss to learn one list, (A-B); followed by a second list, (B-C); followed by still a third, or critical list, (A-C). Performance on the final list is believed to be based on the use of an established mediational chain; namely, A-B-C. In other words, the "B" terms are believed to form a simple mediational link between "A" and "C".

Although most investigators have adopted this paradigm in an unmodified form, a few others have utilized minor variations in design. The B-C relationship, for example, is sometimes assumed to exist, and therefore only one training list, A-B, is presented (Foley and Cofer, 1943; Russell and Storms, 1955; and, Barnes and Underwood, 1959). The direction of the relationships established in the training phase has also been varied (Horton and Kjeldergaard, 1961). Finally, different forms of learning, such as serial lists have been used to establish the mediational chain (Foley and Cofer, 1943; and Richardson, 1962).

The results of studies based on this approach are somewhat contradictory. The majority of investigators report that the establishment of a mediational chain via previous training facilitates performance on the final list (Foley and Cofer, 1943; Murdock, 1952; Bugelski and Scharlock, 1952;

Russell and Storms, 1955; Horton and Kjeldergaard, 1961; Richardson, 1962, 1966; Schulz and Lovelace, 1964; Goulet, 1966; and Shanmugan and Miron, 1966). But other authors maintain that little or no mediation occurs as a result of training (Peters, 1935; Katona, 1960; Barclay, 1961; and Mandler and Earhard, 1964).

Two of the latter authors have proposed alternative explanations for the positive effects which have been observed. Barclay (1961), for example, found that differential reinforcement in the establishment of the B-C associations had no effect on the comparative speed with which the A-C associations were formed. He therefore argued that the facilitating effects which were reported in other studies could be attributed to general transfer of training such as "learning to learn" or to simple stimulus generalization without any reference to mediation. But the findings on which this conclusion is based have not gone unchallenged. Shanmugan and Miron (1966), for example, found that transfer did increase as the degree of learning on the second, (B-C), list increased.

Mandler and Earhard (1964) have also proposed an alternative. These authors demonstrated that a list of A-E associations is learned more rapidly when preceded by lists A-B and B-C than when preceded by lists A-B and D-C. They therefore argued that as learning progresses on the second, (B-C), list, the A-B associations undergo extinction in the experimental paradigm (A-B, B-C, A-C), while remaining intact in the

control paradigm (A-B, D-C, A-C). These intact A-B associations then interfere with the formation of A-C associations for Ss in the control group, while no comparable interference is present for Ss in the experimental group. It is, therefore, the presence or absence of interference conditions rather than the presence or absence of mediational chains which gives rise to the obtained differences in performance between these two groups. But these conclusions have also been challenged. Goulet (1966), for example, found that the retention of A-B associations following second list learning was as high, or higher, under experimental conditions as under control conditions.

It therefore seems reasonable to conclude that the establishment of mediational chains (encoding schemes) does facilitate performance on the critical A-C lists. Further, the extent to which these chains facilitate performance has been shown to be directly related to the degree of second stage learning (Shanmugan and Miron, 1966); the length of the anticipation interval (Schulz and Lovelace, 1964; and Richardson, 1966); and the polarization of the mediating ("B") terms (Shanmugan and Miron, 1966). In short, the procedure of establishing a coding scheme via training on other paired associate lists has been reasonably fruitful in answering the general question of whether or not coding schemes have an effect on the formation of verbal associations.

The second technique--presentation of a single list, followed by verbal reports--has yielded an even more definitive answer to this basic question. This technique was used as early as 1918 when Reed (1918) presented Ss with a series of paired-associate lists and then asked them to report any aids which they had interjected between the stimulus and response terms. He found that whenever an associational aid was reported, the corresponding pair of terms was learned more rapidly and retained longer than pairs for which no association was reported. Reed also developed a crude classification system of the types of associations which were formed. He noted, for example, that logical associations have a greater impact on performance than associations based on some "likeness in sensory quality" such as the sound or sight of letters.

Reed's study was apparently followed by a long interval in which psychologists failed to ask Ss how they formed associations. Beginning about ten years ago, however, verbal reports began to find their way back into studies of paired-associate learning. Use of this procedure by contemporary psychologists has confirmed most of Reed's original findings.

In 1957, for example, Rock (1957) collected verbal reports following a paired-associate task. Noting that most Ss derived at least some mnemonic devices in forming the associations, Rock stated . . .

> The theoretical significance of the widespread use of such devices in rote learning experiments has not been sufficiently emphasized in the past. The successful use of such devices may mean that an idea suddenly

> occurs to a S which enables him to link two items then and there; it has, to some extent, the character of insightful learning. (Rock, 1957, p. 191.)

It remained for Mattocks (as reported in Underwood and Schulz, 1960) to show that these devices aid in the formation of verbal associations. Mattocks collected verbal reports following a paired-associate task which involved low meaningful trigrams as stimulus terms and common three letter words as response terms. He found that pairs which were linked by some mediational scheme involving pre-existing associations were learned more rapidly than pairs for which the S reported no associations. Using a somewhat different approach, Clark, Lansford, and Dallenbach (1960) reported that under experimental conditions which favored the formation of mnemonic devices (e.g., long intertrial intervals and long exposure times), verbal associations were formed almost twice as rapidly as under conditions which did not favor the formation of these devices. Verbal reports were used to confirm the speculation that these differences in rate of learning were the result of differences in the extent to which Ss were able to form and utilize mnemonic devices.

In 1961, Bruner (1961) developed a crude scheme for classifying associative aids. He found that the aids which children used in forming associations between familiar words almost always involved one of three general types of relationship--equivalence, thematic, or functional. Perhaps more important, Bruner also noted that those pairs which were linked by the type of relationship which a given youngster used most frequently were learned more rapidly than pairs linked by one of the other two types of relationship. In a more recent study, Martin, Boersma, and Cox (1965a) developed an elaborate scheme for classifying associative aids used during associational tasks which involve nonsense syllables as stimulus and response terms. These authors found that each reported "associative strategy" could be reliably ordered along a dimension of cue complexity which ranged from no reported association to syntactical strategies. More important, these authors also reported that the speed with which a given association is formed is directly related to the level of the associative strategy which the individual reports. In an extension of this research, Martin, Cox, and Boersma (1965b) demonstrated that the general level of strategy which is derived by a given S is a direct function of the meaningfulness of the items which are presented. These authors also found that differences in meaningfulness of the stimulus terms have a greater effect on general strategy level than corresponding differences in response terms.

All of the above investigators have been concerned with coding schemes which somehow unite a single pair of terms, i.e., first-order coding schemes. However, Battig (1966) obtained some evidence in the verbal reports of Ss which indicated that they frequently formed groups consisting of two or more pairs, instead of learning each pair independently.

He therefore undertook a series of experiments which demonstrated that under experimental conditions which facilitated the formation of "higher-order multiple pair chunks" on the basis of degree of learning, associations were formed more rapidly than under conditions which did not facilitate such grouping. This research suggests that the encoding process does not always terminate with the derivation of a set of first-order coding schemes, as the other investigations in this area have assumed.

The third approach--presentation of some form of encoding scheme as a part of the general instructions--has also yielded a set of conclusive findings. Studies involving this approach present one group of Ss with a set of coding schemes prior to the initial presentation of the list; while a second, or control group is not presented with these aids.

The encoding schemes which are most frequently presented are sentences which unite the two words or two nonsense syllables in each pair (e.g., Someone was playing a DRUM in a TENT). Sentences of this type have been shown to aid in the formation of associations between pictures of familiar objects which are presented to mentally retarded adults (Jensen and Rohwer, 1963a), as well as in the formation of associations between nonsense syllables presented to fourth through sixth grade children (Cox, 1965).

Using a slight variation of this technique, Spiker (1960) has shown that the presentation of sentences during a practice list aids fifth grade youngsters in forming associations on a second, or critical list. In a comparable study, Bruner (1961) contrasted the effectiveness of coding schemes derived by individual Ss with those presented by the experimenter. In this study, one group of twelve year old Ss was told to produce a word, or an idea which would tie each pair of words together. A second group was then presented with the mediators derived by Ss in the first group. The performance scores of Ss in the self-mediational group were clearly superior to that of Ss in the second group. These four studies, therefore, provide convincing evidence that imposed coding schemes facilitate the formation of associations.

But, contrary to what one might expect, these aids do not appear to reduce the differences in speed of learning which occur among children when no aids are given (Davidson, 1964; and Cox, 1965). And, the effect of these aids on long-term retention is also somewhat questionable. Martin, Cox, and Bulgarella (1966), for example, found that the two-day retention of a group of children who were given a set of first-order coding schemes during acquisition was superior to that of a comparable group who were not given these aids. Jensen and Rohwer (1963a), on the other hand, found no differences in the seven day retention of a group of mentally retarded adults who were given a set of coding schemes during acquisition and a comparable group who were not given these aids.

But, as indicated earlier, there can be little doubt that imposed coding schemes do facilitate the formation of associations. The critical function which these aids serve in this regard, appears to be that of somehow uniting the two terms in each pair.

Epstein, Rock, and Zuckerman (1960), for example, devised three methods of presenting the same six pairs of concrete nouns. In list one, the two nouns were connected in meaningful units by the addition of a single term (e.g., CAKE near ROAD). In list two, a grammatically equivalent term was interjected between the two nouns, but the addition of this term did not form a unit (e.g., CAKE and ROAD). Finally, a third list was devised which did not involve any extraneous terms (e.g., CAKE - ROAD). Following a single presentation of the list, the mean number of words correctly anticipated was computed. Scores on list one (meaningful units) were clearly superior to scores on the other two lists. In a comparable study with children, Davidson (1964) found that supplying a prepositional link between each pair (e.g., shoe on chair) was as effective as a picture showing this condition, accompanied by a sentence describing the picture (e.g., large shoe resting on the arms of a chair). These two studies, therefore, clearly demonstrate that the effectiveness of various encoding schemes which are utilized during paired-associate learning stems from the fact that these schemes somehow unite the two terms in a given pair.

The final procedure which has been used to determine the role of encoding schemes in associational learning has been to present lists which have some form of "built-in" coding scheme. In perhaps the only study which has utilized this technique, Underwood and Erlebacher (1965) presented lists of stimulus and response trigrams. These lists were constructed in such a way that the letters in each trigram could be rearranged to form familiar words. They found that most Ss formed words during encoding. But, the use of this coding scheme facilitated performance only under those conditions in which the letters in each trigram had been rearranged according to a single rule. When Ss were required to use more than one decoding rule, use of the "built-in" coding schemes had little or no effect on performance. Unfortunately, however, the imposed coding scheme in this study was aimed at facilitating either response learning or the formation of discriminations among highly similar stimuli. It did not serve the function of somehow uniting the two terms in each pair.

The combined results of studies reviewed in this section leave little doubt that the derivation of encoding schemes facilitates the formation of verbal associations. There is even evidence to suggest that some "strategies," or encoding schemes, which are used to link nonsense syllable pairs may be more effective than others (Martin *et al.*, 1965a). Research in this area has also identified the critical function which these coding schemes serve; namely, joining pairs of terms into some meaningful unit (Epstein, Rock, and Zuckerman, 1960; and Davidson, 1964). In short, a general appraisal of the research in this area tempts one to conclude that the major issues have been largely exhausted.

But a closer review reveals at least two major shortcomings of the existing research. First, the full range of procedures which might be used to study the encoding process during associational learning is far from exhausted. Underwood and Erlebacher (1965), for example, are perhaps the only authors to use the technique of deriving lists with some form of "built-in" structure. Yet, as noted in Chapter I, the use of this technique has proved its value in studies which involve the free recall of serial lists.

Second, with the exception of Battig (1966), no one has traced the encoding process beyond the formation of relations between each pair of terms, i.e., first-order coding schemes. Yet, as Battig (1966) notes, general descriptions of the encoding process seem to suggest that Ss will attempt to form fewer units of retention than there are pairs on the list. Thus, studies which examine only intra-pair associational aids do not seem totally consistent with general descriptions of the encoding process.

III. General Evidence Related to the Stated Problem of this Investigation

A. The Effect of Higher-Order Coding Schemes on Short-Term Retention

As noted above, Battig's (1966) research represents the only investigation of associational learning which has traced the encoding process beyond the derivation of a set of first-order coding schemes. Thus, Battig is the only investigator to provide direct evidence for the assertion that the derivation of higher-order coding schemes facilitates the formation of verbal associations. And even this evidence may be questioned on several grounds. First, in terms of methodology, Battig has failed to control certain extraneous conditions such as the presence or absence of serial position cues which may have also contributed to his obtained results. Second, Battig's assertion that Ss group pairs on the basis of item difficulty or degree of learning is reasonable only if one assumes that the experimental conditions have effectively prevented a S from adopting a more efficient strategy.

Bruner's study (1961), for example, suggests that Ss are more likely to initially attempt to derive the same relationship among the terms in more than one pair. Bruner observed that children usually exhibit a strong preference in the type of relationship which they form between pairs of familiar terms. Furthermore, those pairs which are linked by the child's favorite type of relationship--equivalence, functional, or thematic--tend to be learned more rapidly than pairs joined by one of the other two types of relationship. Thus, Bruner might have argued that Ss group pairs on the basis of the type of relationship which they have established between each. But Bruner's failure to provide any statistical evidence for his assertions severely limits the strength of any such argument.

In short, investigations of associational learning have provided only equivocal evidence for the general hypothesis that the derivation of higher-order coding schemes will facilitate the formation of verbal associations. However, indirect evidence is provided by the results of investigations involving other types of learning.

Studies involving the free recall of serial lists, for example, have shown that recall is improved when Ss transform letter trigrams into common words (Underwood and Keppel, 1963; and Lindley, 1963); when Ss alphabetically organize lists of unrelated nouns (Tulving, 1962; and Earhard, 1967); when Ss group words according to common categories (Reid, Brackett, and Johnson, 1963); and when Ss link words through the use of well-established grammatical rules (Miller and Selfridge, 1950; Marks and Jacks, 1952; Richardson and Voss, 1960; Tulving and Patkau, 1962; and Coleman, 1962). Collectively, these studies suggest that a S's active attempts to reduce the number of units of retention ultimately facilitate short-term retention. It is therefore at least logically consistent to assert that similar attempts in associational learning will also facilitate acquisition.

B. The Effect of Higher-Order Coding Schemes on Long-Term Retention

Although available evidence leaves little doubt that the use of first-order coding schemes facilitates the formation of verbal associations, one can only speculate as to their effect on long-term retention. Martin _et al._, (1966) and Jensen and Rohwer (1963a) appear to be the only authors to ever examine the effect of coding schemes on the long-term retention of verbal associations. And, these two studies were not only limited to a concern with first-order coding schemes, but they also yielded contradictory results. Thus, studies of associational learning do not even provide indirect evidence for the general hypothesis that the derivation of higher-order coding schemes will aid in the long-term retention of verbal associations.

As noted earlier, however, the derivation of higher-order coding in this investigation might be said to correspond to the discovery of a principle. Therefore, studies which have been concerned with the retention of principles may also be relevant to this hypothesis. Unfortunately, however, most studies which have focused on the formation and retention of principles have been concerned with problem-solving or non-reproductive forms of learning rather than with the use of principles as aids in storing and retaining information.

There is a sizable body of research, for example, which is concerned with the basic question of whether or not some form of aid in deriving the relevant principles will have any impact on an individual's ability to solve a given set of problems.[7] When retention is determined in these studies, it is usually expressed in terms of an individual's ability to apply the relevant principles to a new set of problems rather than in terms of retention of information which has been organized around some principle.

Occasionally, however, these investigations have also examined the effect of various forms of training on the long-term retention of information; namely, retention of the solutions to a given set of problems. Results of studies in this area have consistently shown, for example, that when

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[7]The results of studies in this area are loaded with contradictions. Several authors, for example, maintain that their results favor the conclusion that some form of guidance or aid in deriving the relevant principles is superior to training involving self-discovery of these principles. Guidance has been shown to aid in both the derivation of solutions to a set of problems (Ewert and Lambert, 1932; Duncker, 1945; and French, 1954) and in an individual's ability to apply these principles to new problem situations (Judd, 1908; Waters, 1928; Katona, 1940; Hendrickson and Schroeder, 1941; Craig, 1953; Kittell, 1957; Corman, 1957; Gagné and Brown, 1961; and Ray, 1961).

However, other authors have been forced to conclude that different levels of guidance do not yield differences in an individual's ability to solve a given set of problems (Olander, 1931; Stacey, 1949; Marks, 1951; and Hilgard, Edgren, and Irvin, 1959) nor in his ability to apply these principles to new problem situations (Thiele, 1938; Hendrix, 1947; Craig, 1956; and Haslerud and Meyers, 1958). Some of these authors have even maintained that self-discovery is superior to some form of guidance.

individuals are given some aid in discovering the principles which underlie the solution to a given set of problems ("guided discovery") they will be able to retain these solutions longer than individuals who are either given a direct statement of the relevant principles, together with the solutions (Kittell, 1957; and Ray, 1961) or those individuals who merely memorize the solutions with no understanding of the underlying principles (a series of studies by Katona, 1940; Swenson, 1945; and Kittell, 1957). Katona (1940), for example, found that a group of Ss who were given some training in deriving the relevant principles retained more solutions to a set of matchstick problems than a group of Ss who originally memorized the solutions to these problems with no understanding of the relevant principle.[8]

There is also some evidence to suggest that individuals who are given direct statements of the underlying principles will retain solutions to a set of problems longer than individuals who are merely instructed that there is a principle which underlies these solutions (Postman, 1954; and Craig, 1956). But Kersh (1958, 1962) maintains that his results support the opposite conclusion; namely, that self-discovery is superior to a statement of the relevant principles.

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[8]It is interesting to note that these differences in long-term retention have occurred despite the fact that Ss are often unable to verbalize the relevant principles. Katona (1940), for example, reported that many Ss who had solved most or all of the retention tasks were nevertheless unable to state the principle. Kersh (1958) also found that only about 50 per cent of the Ss could remember the relevant rules four weeks after acquisition.

Collectively, these studies suggest that Ss who discover the relevant principle during acquisition should retain the associations longer than Ss who initially memorize these associations, i.e., form no coding schemes whatsoever. In fact, these studies even suggest that these differences should increase over time (Katona, 1940; Postman, 1954; Kittell, 1957; and Ray, 1961). But, this research has little to say regarding the contrast in long-term retention between Ss who have derived a higher-order coding scheme and Ss who have derived a set of first-order coding schemes. Thus, these studies provide only partial support for the hypothesis that the derivation of high-order coding schemes will aid in the long-term retention of verbal associations.

C. The Role of Perception in the Formation of Higher-Order Coding Schemes

To the author's knowledge, no one has examined the effect of perceptual variables on the discovery of relations among pairs of stimulus and response terms. Consequently, there is no direct evidence to support the general hypothesis that a S's overall perception of the stimulus and response terms will affect the likelihood that he will derive a higher-order coding scheme.

The source of this hypothesis must, therefore, be traced to a group of studies which have shown that perceptual variables affect the probability that Ss will discover implicit relations among a series of numbers (Katona, 1940; Duncker, 1945; Kersh, 1958; and Wertheimer, 1959). Consider the following example from Katona (1940). Suppose that three individuals are presented with the number series which was described in Chapter I and are asked to recite each digit in the order in which it is presented. Further imagine that this series is displayed to each individual in a different manner, such as . . .

individual no. 1: 2, 5, 8, 1, 1, 1, 4, 1, 7, 2, 0
individual no. 2: 258, 111, 417, 20
individual no. 3: 2, 5, 8, 11, 14, 17, 20

Because people tend to group on the basis of contiguity, it seems reasonable to predict that individual three is more likely to perceive the implicit relation among the numbers than either individual one or individual two. In other words, individual three is most apt to reduce the entire series to a single unit of retention, i.e., a statement of this relationship.

Derivation of a higher-order coding scheme in this investigation involves an analogous discovery of an implicit categorical relation among the terms in each triad. It therefore seems reasonable to predict that any method of presenting each triad which somehow makes this categorical relation more obvious should ultimately affect the probability that a given S will derive a higher-order coding scheme.

These logical assertions give rise to a second basic assumption of this dissertation; namely, the categorical terms in each triad are more suggestive of the "built-in" principle than either of the exemplar terms. Based on this assumption, two methods of drawing attention to the categorical terms will be utilized in an attempt to determine whether or not perceptual variables have any effect on the likelihood that a given S will derive a higher-order coding scheme.

The first variable involves differences in the size of print--the categorical terms will either be capitalized with exemplar terms written in small print, or all three terms will be written in small print. A number of studies support the assertion that isolating the categorical terms in this fashion should result in differential attention to these terms (Kohler and Von Restorf, as described in Katona, 1940; Siegel, 1943; Pillsbury and Raush, 1943; and Kimble and Dufort, 1955). The second variable involves differences in the order of presenting the three terms--the categorical terms will either be presented in the first position in all nine triads, or their position will vary from one triad to the next. This variable is based on evidence from a series of studies which suggests that differential attention is usually given to the first term in a series (Cofer, 1963; Howes and Osgood, 1954; Asche, 1946; Astin and Ross, 1958; and Suppes, 1963).

This study will also consider a third perceptual variable which does not involve the assumption that the categorical terms are more suggestive of the principle than the exemplar terms. Either one or two terms in each triad will be written as homonyms. Those Ss presented two-homonym lists must transform two terms in each triad before the underlying categorical relationship is apparent, while Ss presented one-homonym lists need only transform one word in each triad. Thus, the "degree of embeddedness" of the underlying relationship should vary for one-homonym and two-homonym lists.

By determining what per cent of the Ss discover the "built-in" principle for each condition on these three variables, it should be possible to determine whether or not a Ss' overall perception of the three terms (configural perception) has any effect on the probability that he will derive a higher-order coding scheme.

CHAPTER III

METHOD AND PROCEDURE

I. General Overview of the Experimental Design

This investigation consisted of two independent experiments. In Experiment I, eight groups of Ss were presented with a list consisting of 27 familiar terms arranged as nine triads. During the learning trials, each triad was projected on a screen for four seconds and Ss attempted to form associations between all three terms. During the test trials, one term from each triad was presented, using a five second exposure, and Ss attempted to write the other two terms.

Each experimental session consisted of eight learning trials and eight test trials. The interval between a given test trial and the following learning trial was fixed at two minutes. During this period, two trained graduate students scored the answer sheets. Those Ss who reached criterion--two consecutive perfect trials--were identified by the scorers during this interval. As each S was identified, he quickly went into the adjoining hall where he completed the Level of Principle Formation Questionnaire. Those Ss who did not reach criterion within eight trials completed the questionnaire immediately after the eighth test trial.

Each of the eight groups in Experiment I received a different list of triads. Each list represented a unique combination of the following three treatment variables:

(1) type of underlying principle--one vs. two homonyms

(2) size of print--all terms in small print vs. categorical term capitalized and other two terms in small print

(3) order of presentation within the triad--categorical term always in the first position vs. position of the categorical term varied from first through third position.

Thus, Experiment I utilized a 2x2x2 factorial design and involved a group testing procedure. The independent or treatment variables are presented above. The four dependent variables are: level of principle formation, total number of words correctly recalled, number of trials to criterion, and number of intrusions in recall.

Exactly three weeks after the initial learning session, the Ss in Experiment I were presented with a single retention test trial. During this trial, one term from each triad was presented, and Ss attempted to write the other two terms. The independent variables on the test for retention were the three treatment variables listed above, as well as the level of principle formation utilized during initial acquisition. The dependent variables were number of words correctly recalled and number of intrusions.

With one major exception, the design of Experiment II was identical to that of Experiment I. This exception was that the eight groups in Experiment II were given only one learning and one test trial. Following the test trial, all Ss completed the Level of Principle Formation Questionnaire.

If perceptual variables do affect relations between terms which Ss perceive and subsequently utilize during encoding, then it is likely that this effect will be most prominent during the first learning trial. Beyond that point, the effect of perception is probably confounded by other variables. Thus, Experiment II was conducted primarily as a test of the hypothesis that perceptual attributes of the stimulus materials affect the perceived relations between terms. Secondarily, Experiment II provided clarification of the general results of Experiment I.

II. Experiment I

Subjects

Two-hundred and eighteen undergraduate students--67 males and 151 females--served as subjects in this experiment. The majority of these students were college sophomores. Each was enrolled in one of eight sections of educational psychology at Michigan State University. During acquisition, one of the eight lists of triads was randomly selected for presentation to a given section.

The sample size was considerably smaller on the test of long-term retention. This reduction resulted from two factors. First, only 157 of the 218 Ss reached criterion within the eight acquisition trials. Second, twenty-one of these 157 Ss were absent on the day retention was determined. Thus the sample was reduced from 218 Ss during acquisition to 136 Ss on the test for long-term retention.

Materials

Nine triads were constructed according to a predetermined relation; namely, when two of the terms in each triad are transformed into their homonyms, they become exemplars of the third or categorical term. These triads formed the basis of two distinct lists. The first list, which shall hereafter be referred to as the two-homonym list, consisted of the nine triads in an unmodified form. The second list, hereafter referred to as the one-homonym list, was constructed by changing one of the terms in each triad into its homonym. Thus, the one-homonym lists have an underlying principle which is different from that for the two-homonym lists; namely, when one of the terms in each triad is transformed into its homonym, two terms are exemplars of the third or categorical term. Both of these lists are presented in Table 1 on the following page.

The frequency of occurrence of each term, as determined by the Thorndike-Lorge word count (Thorndike and Lorge, 1944) is also depicted in Table 1. Due to the nature of the underlying principles, it was impossible to equate the one and two-homonym lists on this variable. Therefore, the unique terms

Table 1. List of triads which were presented during the study. Numbers in parentheses indicate the number of times per million that the words occur in printed text. (Thorndike and Lorge, 1944.)

Common Terms		Unique Terms		
categorical	misspelled exemplar	two-homonym lists	(or)	one-homonym lists
mammal (6)	dear (AA)	bare (A)		bear (AA)
metal (A)	steal (A)	led (AA)		lead (AA)
receptor (*)	knows (AA)	ayes (16)		eyes (AA)
study (AA)	reed (22)	rite (10)		write (AA)
weather (AA)	son (AA)	rein (25)		rain (AA)
food (AA)	meet (AA)	foul (27)		fowl (20)
appendage (3)	tale (A)	feat (13)		feet (AA)
beverage (8)	bier (4)	whine (11)		wine (A)
group (AA)	teem (6)	heard (AA)		herd (37)

(*) not listed
(A) 50-100 times/million words
(AA) 100 or more times/million words

on one-homonym lists occur somewhat more frequently than the corresponding terms on two-homonym lists.

Type of underlying principle was only one of the stimulus variables examined in this study. Variations in the method of presenting the stimuli gave rise to two additional variables. The first of these variations involved differences in the size in which the terms were printed--either the categorical term was written in capital letters with exemplar terms in small letters (caps condition) or all three terms in each triad were printed in small letters (no-caps condition). The second variation involved differences in the order of presentation of the three terms within each triad--the categorical term was either fixed in the first position on all nine triads (fixed condition), or its position varied such that it appeared in the first position on triads 1, 4, and 7; in the second position on triads 2, 5, and 8; and in the third position on triads 3, 6, and 9 (random condition). In short, all possible combinations of conditions along the three variables led to the development of eight distinct lists of triads.

The final phase of the construction of materials involved the development of stimulus lists for presentation during the test trials. The selection of one term from each triad gave rise to three different stimulus lists for both the one- and two-homonym conditions. By assigning each term in a triad to a different stimulus list, a given term appeared as a stimulus on every third test trial.

Due to potential differences in the recall of categorical terms as opposed to exemplar terms or in the recall of words in different positions within the triad, each stimulus list was counterbalanced for type of word and position within the triad. Thus, each stimulus list consisted of three terms of each type (categorical, exemplar, and misspelled exemplar) as well as three terms which appeared in each position within the triad (first, second, and third). Once this balance was insured, the order of presentation of the nine terms in each of the three stimulus lists was determined by a table of random numbers. In this fashion, order of presentation was altered from test trial to test trial, thereby counteracting the potential effects of serial position cues. Examination of Table 17 of Appendix C, which depicts the mean number of words recalled for every triad over the first three test trials, reveals that this procedure did eliminate systematic serial effects.

Construction of the three stimulus lists for the one-homonym condition preceded the construction of the three lists for the two-homonym condition. The latter lists were identical to the one-homonym lists except that the unique terms were replaced by their corresponding terms on the two-homonym lists. (Terms in column four of Table 1 were replaced by the corresponding terms in the third column.)

The eight lists of triads as well as the six stimulus lists were transferred to slides for display during the learning and test trials. Each list of triads consisted of nine slides with three terms on each, while the stimulus lists consisted of nine slides with a single term on each. A carousel slide projector was used for the display of the fourteen lists.

Procedure

Each experimental session began with a general set of instructions which described the nature of the task (see Section I of Appendix A). The nine slides in the list of triads were then projected on a screen in the front of the room. A four-second exposure time was used for each slide during this and later learning trials.

The first learning trial was followed by a second set of instructions (see Section II in Appendix A). This set of instructions served two functions. First, it described the appropriate way to complete the answer sheets. Second, an attempt was made to maximize the number of intrusions in recall through presentation of the following paragraph:

> Other studies have shown that those people who write the most responses in situations like this usually learn the list fastest. So even if you aren't sure of the answers, write whatever comes into your mind as I show each slide.

The nine slides in the first stimulus list were then projected. A five-second exposure time was used for each slide during this and later test trials. The first test trial was followed by a third set of instructions (see Section III in Appendix A). These directions stressed that Ss were to remain quiet during the intertrial interval. They also restated that the scorers would identify those Ss who reached criterion on a given test trial.

When the two-minute interval elapsed, the second learning trial was presented, followed by the second test trial. The complete experimental session consisted of eight learning and eight test trials.

During every intertrial interval, two trained graduate students collected and scored the answer sheets. Responses of those Ss who received a perfect score on the preceding trial were scored first. In this manner, it was possible to rapidly identify any S who reached criterion.[9] As each of these individuals was identified, he quickly left the room and went into the adjoining hall where he completed the Level of Principle Formation Questionnaire. The time needed for identifying Ss who reached criterion occasionally extended beyond two minutes, but never exceeded two and one-half minutes.[10]

A test of long-term retention was administered three weeks after the initial acquisition session. Ss had not been informed that they would be tested for long-term retention. Each experimental session was introduced by a set of general instructions (see Section IV in Appendix A). The instructions were followed by a single test trial.

There were two differences between the test of long-term retention and earlier tests of short-term retention. First, the list of stimulus terms consisted of all nine categorical terms, rather than three categorical terms and six exemplar terms. This change was introduced to maximize the likelihood of making errors in spelling the misspelled exemplar terms. Second, each slide was projected for eight seconds, instead of five seconds. This change was introduced to give each S more time to think through his responses.

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[9]Minor deviations in the spelling of the categorical terms were the only errors which were tolerated in this scoring.

[10]Most apt to be true for intervals following the third, fourth, and fifth test trials.

III. Experiment II

Subjects

A total of 244 Ss--94 males and 150 females--participated in Experiment II. These Ss were enrolled in one of six sections of educational psychology or four sections of educational philosophy at Michigan State University. Four of the sections of educational psychology were considerably smaller than the others. These four groups were therefore arbitrarily treated as two experimental groups. These two condensed groups, as well as the other six sections with typical enrollment, were then randomly assigned to one of the eight list conditions.

Materials

The eight lists of triads were identical to those employed in Experiment I.

Procedure

With the exception of two changes in directions, the procedure adopted for Experiment II was identical to that utilized for the first learning and first test trials of Experiment I. As noted earlier, the list of triads was presented for a single learning trial at a 4-second rate, followed by a single test trial using a 5-second exposure. All Ss completed the Level of Principle Formation Questionnaire immediately after the test trial.

The first change in directions involved the general instructions which were given prior to each experimental session. Although the general content of these instructions was identical for both experiments, some of the statements which were included between the first learning and first test trial of Experiment I were made prior to the first learning trial of Experiment II. (These differences are depicted in Sections I and II of Appendix A.) The purpose of this change was to reduce the length of the intertrial interval as well as the extent of interference caused by reading directions at this point. In short, an attempt was made to reduce the extent of influence which either of these factors may have had on the relationship between the levels of principle formation derived during the first learning trial and performance on the first test trial.

Whether or not this change in directions resulted in a loss of generality between the results of Experiment I and Experiment II is contingent upon the dependent variable which is being considered. It is likely, for example, that the number of words recalled on the first test trial will be somewhat higher for Experiment II than for Experiment I. But this change should have no effect on the per cent of Ss who discover the principle during the first learning trial of either experiment. In general, the minor difference in directions between Experiment I and Experiment II does not preclude attempts to formulate generalizations based on the combined results of these two experiments.

The second change in directions involved the instructions which were given to each S as he attempted to complete the Level of Principle Formation Questionnaire (L.P.F.Q.). Whereas Ss in Experiment I received only those directions which are printed on the cover of this instrument, Ss in Experiment II were given a special set of oral instructions immediately after the questionnaires had been distributed (see Section V of Appendix A). These instructions emphasized that Ss would not answer questions on every page of the L.P.F.Q. Thus, this change in directions was introduced in an attempt to increase the reliability of the L.P.F.Q.

IV. Level of Principle Formation Questionnaire

A reexamination of the hypotheses in Chapter I clearly suggests that the level of principle formation variable occupies a central role in this investigation. In nearly every hypothesis this characteristic functions as either an independent or a dependent variable. The instrument designed to determine values along this variable is referred to as the Level of Principle Formation Questionnaire (L.P.F.Q.).

Presented in Appendix B, the L.P.F.Q. is designed somewhat like a branched program in that the particular manner in which a S responds to a given question determines what question he shall answer next. By examining a given S's pattern of "yes" and "no" responses, it is possible to operationally assign him to one of four levels of principle formation.

This operational classification scheme is presented in Table 2 below:

Table 2. The operational criteria used to assign individuals to one of four levels of principle formation according to their responses to the Level of Principle Formation Questionnaire.

Level	Descriptions	Operation underlying assignment to this level
I	Neither looks for, nor formulates any first-order coding schemes.	Answers "no" to first two questions (page 1).
II	Formulates at least some first-order coding schemes.	Answers "yes" to one question on page 1, but "no" to the question on page 2.
III	Discovers some common first-order coding schemes, but does not discover the principle.	Answers "yes" to questions on page 1 and 2, but "no" to question on page 3. Provides evidence for assertion on page 4.
IV	Discovers the underlying principle.	Answers "yes" to all relevant questions on first three pages, and correctly performs at least one of the two tasks on pages 5 and 6. (Incorrect completion of both tasks will result in assignment to Level III)

Numerous potential assets of the questionnaire, such as the operational scheme for classifying Ss, led to the decision to adopt the L.P.F.Q. during this investigation despite the fact that it had never been tested with a group of undergraduate students. But, in practice, the questionnaire proved to have two inherent weaknesses. First, despite the inclusion of an example to clarify the question, the query on page two showed definite signs of ambiguity. Several Ss who answered this question "no" (thereby indicating that they had not discovered the principle), nevertheless, produced nine verbal reports on page four which all conformed to statements of the principle. Second, the general directions on the first page did not sufficiently emphasize that Ss would not answer questions on every page. As a result, the specific directions at the end of each question (which revealed the next question to be answered) were often ignored. The fact that many Ss in Experiment I were not allotted ample time to complete the questionnaire may have also contributed to this general failure to follow directions. Whatever the source, an alarming number of errors occurred. Ninety of the 218 Ss in Experiment I, or roughly forty-one per cent, made one or more errors in following directions.

Fortunately, the number of errors made by Ss in Experiment II was substantially reduced by two changes in procedure. First, Ss in this experiment were given unlimited time in which to complete the form. Second, these Ss were also given special verbal instructions which emphasized that they would not answer questions on every page.[11] Despite these changes,

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[11]These directions are presented in Section V of Appendix A.

the performance of Ss in Experiment II was far from perfect. Twenty-seven of the 244 Ss in this group, or roughly twelve per cent, made one or more errors in completing the questionnaire.

The obvious bias which would result from the deletion of 117 Ss from the sample forced the investigator to make two basic changes in the classification scheme which is presented in Table 2 above. First, only two levels of principle formation were determined instead of four. Second, verbal reports were used as a supplementary basis for identifying Ss who had discovered the principle. These two changes circumvented the problems arising from the two inherent weaknesses of the L.P.F.Q. while in no way altering the major purpose of this study.

The first major change was to collapse levels I, II, and III into a single category; namely, those who did not discover the principle. This decision was based upon the apparent failure of the L.P.F.Q. to make any useful discriminations between Ss at the lower levels of principle formation. In brief, no S could be classified at level I under any set of criteria, and Ss classified at levels II and III according to a somewhat modified scheme (identification sometimes based on verbal reports) did not differ in performance on any of the following five dependent variables: total number of spelling errors; number of trials to criterion; number of words correct on the test for long-term retention; and, numb

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number of words correct on the first test trial of Experiment II. The series of one-way analysis of variance tests upon which this statement is based are summarized in Table 18 of Appendix C. In view of this finding, it would seem reasonable to assume that levels I, II, and III would have been collapsed into a single category even if every S in the sample had followed directions.[12]

The second, and perhaps more basic change, was to classify Ss into the two categories on the basis of verbal reports on page four, or on the basis of the performance measures on pages five and six, depending on which they completed first. The pattern of "yes" and "no" responses which were basic to the original classification system were to a large extent ignored in the final system. This change, which circumvented problems arising from the frequent failure to follow specific directions is depicted in Table 3 on the following page. Those Ss who met any of the four criteria which are listed in this table were included in the group which discovered the principle. All others were classified as members of the group which did not discover the principle.

Two analyses were undertaken in an attempt to provide empirical support for the final classification scheme.

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[12]The apparent failure of the L.P.F.Q. to discriminate between Ss at the lower levels eliminated any opportunity to test a model of principle formation which this author had derived as a supplemental phase of the investigation. In view of these non-test conditions, reference to this model was deemed extraneous to the major purpose of the investigation, and has therefore been deleted from this report.

Table 3. The four criteria ultimately adopted to identify Ss who discovered the principle during acquisition.

Criteria	Improvement	Description
I	Circumvents the problem arising from the ambiguity of the question on page 2.	Answers "no" to the question on either page 2 or 3, yet for all nine verbal reports on page 4 the S: (1) stated that two of the words were exemplars of the third or categorical term, and (2) indicated the appropriate changes for the misspelled exemplar term(s).
II	Circumvents many of the problems surrounding the failure to follow specific directions at the end of each question.	Same as Criterion I, except that S answered questions on first three pages "yes", but then completed the verbal reports on page 4 prior to the performance tasks on pages 5 and 6.
III	None	Answers questions on first three pages "yes" and turns directly to page 5 where completes <u>one</u> of the two tasks correctly.
IV	None	Same as Criterion IV, but completes both performance tasks correctly.

First, it was necessary to show that the first two criteria listed in Table 3 above which were added to the list were as effective in identifying Ss who discovered the principle as the third and fourth criteria which were carried over from the original classification system. Second, because it was no longer possible to classify every S on the basis of operational criteria, the reliability of the final scheme was determined.

A careful appraisal of Table 3 above reveals that basic differences exist among the four criteria, perhaps the most important of which is that Criteria I and II involve an analysis of verbal reports, while Criteria III and IV are based on the successful completion of at least one performance task. In view of these differences, it seemed desirable to demonstrate that the performance of Ss identified as discoverers of the principle would not vary significantly across the four criteria. Only if this equality of performance prevails, for example, is it safe to assume that verbal reports are as valid as performance tasks in identifying Ss who have discovered the principle. In an attempt to confirm this assertion, the author hypothesized that the means for all four groups of Ss (corresponding to the four criteria) would be equal on each of the following dependent variables: number of words correctly recalled over all eight test trials; total number of misspelled exemplar terms; number of trials to criterion; and, number of words correctly recalled on the test of long-term retention.

The obtained sample means and sample variances for the four groups of Ss identified as discoverers of the principle by each of the four criteria are depicted in Table 19 of Appendix C.[13] Examination of this table reveals that the

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[13]The one and two homonym lists have been analyzed independently in view of the differences in both terminology and

four means are extremely close on each of the four dependent variables. This apparent equality prevails on both one- and two-homonym lists. Nevertheless, a one-way, fixed-effects, analysis of variance test was computed for each measure, the results of which are also depicted in Table 19. Available tables in Guenther (1964) reveal that none of these differences is significant when alpha is equal to 0.10. In fact, only one difference is significant when alpha is equal to the extremely low value of 0.25.[14] In view of this apparent lack of difference in performance among the four groups, it seems reasonable to conclude that the four criteria are equally effective in identifying Ss who have discovered the principle. The low values of alpha upon which these decisions to accept the null hypothesis are based lends further support to this conclusion. Under these conditions, the probability of making a type II error is quite small.

As a second phase in the evaluation of the final classification scheme, interjudge reliability was determined. Two different individuals were involved in this analysis. The first classified Ss in Experiment I, while the second classified

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underlying principles on these two lists. Because of these differences, the distinction between the two lists shall be maintained throughout the dissertation.

[14]When this test was followed by the Scheffé test of individual comparisons, the results suggested that the mean number of words recalled by Ss classified on the basis of verbal reports (criterion I) surpassed the corresponding mean for individuals classified on the basis of performance tasks (criterion IV). This result occurred on the test of long-term retention of one-homonym lists ($0.10 < p < 0.25$).

Ss in Experiment II. Training for these two independent judges consisted of general instructions, followed by practice on one of the eight lists selected at random. Disagreements in classification on the practice list were carefully analyzed by the principal investigator and the independent judge. Once this training was complete, the two judges made independent classifications on the remaining seven lists in Experiment I and Experiment II respectively.

In view of the classification of Ss into only two categories, Phi coefficients were computed for both experiments. In order to compute this statistic, it was necessary to assign every individual in the sample to one of the two categories.[15] This procedure yielded 15 disagreements among the independent judge and principal investigator for 190 Ss in Experiment I, and seven disagreements for 210 Ss in Experiment II. The corresponding Phi coefficients were 0.840 and 0.914.[16]

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[15]During later analyses, however, the principal investigator treated 13 Ss in Experiment I and 15 Ss in Experiment II as "unclassifiable." The reasons for excluding these Ss from the final sample included: ambiguous verbal reports; failure to answer all relevant questions; and, gross inconsistencies between verbal reports and performance tasks. As will be shown in Chapter IV, the levels of performance of these individuals consistently fell between Ss who either did or did not discover the principle. Therefore, exclusion of these Ss from the sample probably had little effect on the overall results.

[16]As a double check on the extent of inter-judge agreement, many of the analyses in Experiment I were repeated for classifications made by the independent judge (see Table 20 in Appendix C). The single instance in which the results of the independent judge differed from those of the principal investigator is noted in the text of Chapter IV. With this single exception, the results of both sets of data led to the same statistical decision.

In summary, the frequent failure of Ss to follow specific directions on the L.P.F.Q. forced this investigator to make two revisions in the classification scheme. First, Ss were assigned to only two groups (discoverers vs. non-discoverers of the principle) instead of four levels of principle formation. Second, verbal reports were used as supplementary sources in identifying Ss who had discovered the principle. The final scheme, involving four distinct criteria, was then evaluated along two dimensions. First, statistical tests with a high level of power revealed that Ss classified as discoverers of the principle, on the basis of verbal reports, exhibited the same mean level of performance across five dependent variables as Ss classified on the basis of performance tasks (criteria used in the original scheme). Second, the inter-judge reliability was shown to be sufficient for the purposes of this study. Phi coefficients of 0.840 and 0.914 were obtained for classifications made by the principal investigator and an independent judge in Experiment I and Experiment II, respectively. In short, the final classification system not only circumvented problems occurring when Ss failed to follow directions, but it also proved to be adequate for the purposes of this study.

Finally, it should be noted that these changes in procedure resulted in changes in the statement of certain hypotheses. In Chapter IV, those hypotheses which were originally phrased in terms of differences among individuals at the four levels of principle formation will be rephrased as a simpler contrast between Ss who either did or did not discover the principle.

CHAPTER IV

RESULTS

I. Definition of the Dependent Variables

The following dependent variables were examined at some point during either Experiment I or Experiment II:

(1) level of principle formation--redefined as per cent of Ss who discovered the principle. Section IV of Chapter III describes how this measure was determined.

(2) number of words correct on a given test trial--Each response on the answer sheet was scored as either "one" or "zero", depending on whether or not it occurred in the triad from which the stimulus word was taken. Spelling of the two exemplar terms had to be exact, whereas phonetically equivalent spellings of the categorical term were scored as "one". The total number of words correct on a given test trial ranged from 0-18.

(3) total number of words correct over all eight test trials--This measure was a simple sum of the number of words correct on test trials 1-8. Those Ss who reached criterion prior to the eighth test trial were scored as 18 for every trial beyond the point where they reached criterion.[17]

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[17]The scorers in Experiment I made twelve errors. Two Ss had three consecutive errorless trials before being told that they reached criterion. Ten others were informed that they reached criterion at the end of their first errorless test trial. It was therefore necessary to interpolate scores for the latter ten Ss along two variables. First, each S was given credit for 18 correct responses on each of the remaining test trials. This interpolation is probably a reasonable estimate of the total number of words recalled since, without exception,

(4) trials to criterion--Criterion was defined as two consecutive perfect trials (scores of 18). Because it was possible to complete only 8 test trials during the class period, this measure was interpolated for several Ss. Those Ss who received scores of less than 18 on the eighth test trial were scored as 10 trials to criterion. Ss who recalled all 18 terms on the eighth test trial, but not the seventh, were scored as 9 trials to criterion.[18]

(5) spelling distortions--total number of responses which were written as homonyms of the correct exemplar terms.

(6) intra-list intrusions--total number of responses which were on the list, but not as a member of the triad from which the relevant stimulus word was taken.

(7) extra-list intrusions--total number of responses which were meaningful words but which were not members of any stimulus triad.

(8) improper plurals--number of plural responses to terms which were singular on the list (e.g., "appendages" instead of "appendage") or singular responses to terms which were plural on the list (e.g., "eye" instead of "eyes"). Plurals involving forms other than simple "s" changes were treated as extra-list intrusions (e.g., "feet" instead of "foot").

(9) total number of intrusions--the sum of all four types of errors (numbers 5-8, above).

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the ten Ss had scores of at least 16 on the preceding test trial. Second, one test trial was added to the number of trials to criterion. This interpolation is probably subject to serious error since a single mistake on the following trial would have resulted in a much higher value.

[18]Ibid.

II. Higher-Order Coding Schemes and Short-Term Retention

Hypotheses one through four predict that the short-term retention of Ss who discover the principle will be superior to that of Ss who do not discover the principle. This prediction is expressed for the performance of Ss over all eight test trials of Experiment I (Hypotheses one and two) as well as the performance of Ss on the first test trial of Experiment II (Hypotheses three and four).

Hypothesis 1:[19] Ss who discover the principle at some point during the learning task will form the required associations more rapidly than those who do not. The corollary hypotheses stated in null form are as follows:

Corollary 1a: The mean number of trials to criterion for Ss who discover the principle will be greater than or equal to the corresponding mean for Ss who do not discover the principle.

Corollary 1b: The mean total number of words correctly recalled over all eight test trials by Ss who discover the principle will be less than, or equal to, the corresponding mean for Ss who do not discover the principle.

Hypothesis 1: With one exception, Ss who discover the principle at some point during the learning task will make fewer intrusions in recall than Ss who do not. The single exception is number of improper plurals, where the opposite prediction is made.[20] The corollary hypotheses, stated in null form, are as follows:

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[19]In accord with considerations advanced in section IV of Chapter III, Hypothesis 1 and all subsequent hypotheses which were phrased in terms of "level of principle formation" in Chapter I have been modified to read as a simple contrast between Ss who either did or did not discover the relevant principle.

[20]This exception is based on a consideration of the grammatical structure of given expressions of the principle. Many of these expressions are apt to include improper plurals; for

<u>Corollary 2a</u>: The mean number of spelling distortions made by Ss who discover the principle will be greater than, or equal to, the mean number of spelling distortions made by Ss who do not discover the principle.

<u>Corollary 2b</u>: The mean number of extra-list intrusions made by Ss who discover the principle will be greater than, or equal to, the mean number of extra-list intrusions made by Ss who do not discover the principle.

<u>Corollary 2c</u>: The mean number of intra-list intrusions made by Ss who discover the principle will be greater than, or equal to, the mean number of intra-list intrusions made by Ss who do not discover the principle.

<u>Corollary 2d</u>: The mean number of improper plurals formed by Ss who discover the principle will be less than, or equal to, the mean number of improper plurals formed by Ss who do not discover the principle.

<u>Corollary 2e</u>: The mean total number of intrusions made by Ss who discover the principle will be greater than, or equal to, the mean total number of intrusions made by Ss who do not discover the principle.

Hypotheses one and two are concerned with measures of performance in Experiment I. Hypotheses three and four, on the other hand, are concerned with performance on the first test trial of Experiment II. Therefore, the dependent variables in hypotheses one and two represent total scores over all eight test trials of Experiment I, while the corresponding variables in hypotheses three and four represent scores on the single test trial of Experiment II. A second distinction between these two sets of hypotheses is that Ss in Experiment I

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example, "the 'eyes' and 'knows' are both 'appendage<u>s</u>'." Discoverers of the principle, using such statements as mediators between the stimulus and overt response, might therefore be expected to form many improper plurals. Ss who did not discover the principle, on the other hand, were expected to derive first order relations which somehow encompassed the three terms in their original form; for example, "An 'appendage' 'knows' what the 'eyes' see."

completed the L.P.F.Q. immediately after they reached criterion or after the eighth test trial (whichever came first), while Ss in Experiment II completed this form immediately after the first test trial. Therefore, "discoverers of the principle" in hypotheses one and two represent Ss who discovered the principle at some point during the learning task, while the corresponding Ss in hypotheses three and four represent those Ss who discovered the principle during the first learning trial.

> Hypothesis 3 (stated in null form): The mean number of words recalled on the first test trial by Ss who discover the principle during the first learning trial will be less than, or equal to the corresponding mean for Ss who do not discover the principle.

> Hypothesis 4: With one exception, Ss who discover the principle during the first learning trial will make fewer intrusions in recall on the first test trial than Ss who do not discover the principle. (The single exception is the number of improper plurals, where the opposite prediction is made.) If scores on the first test trial of Experiment II are interchanged with scores over all eight test trials of Experiment I, the five corollaries of hypothesis four are identical to those of hypothesis two. For purposes of convenience, therefore, the corollary hypotheses of hypothesis four are expressed as follows:
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> Corollary 4a: Same as Corollary 2a.
> Corollary 4b: Same as Corollary 2b.
> Corollary 4c: Same as Corollary 2c.
> Corollary 4d: Same as Corollary 2d.
> Corollary 4e: Same as Corollary 2e.

Figure 1 on the following page depicts the learning curves for Ss who either did or did not discover the principle at some point during Experiment I. The curves for Ss presented one- and two-homonym lists are portrayed independently due to the differences in both terminology and underlying principles on

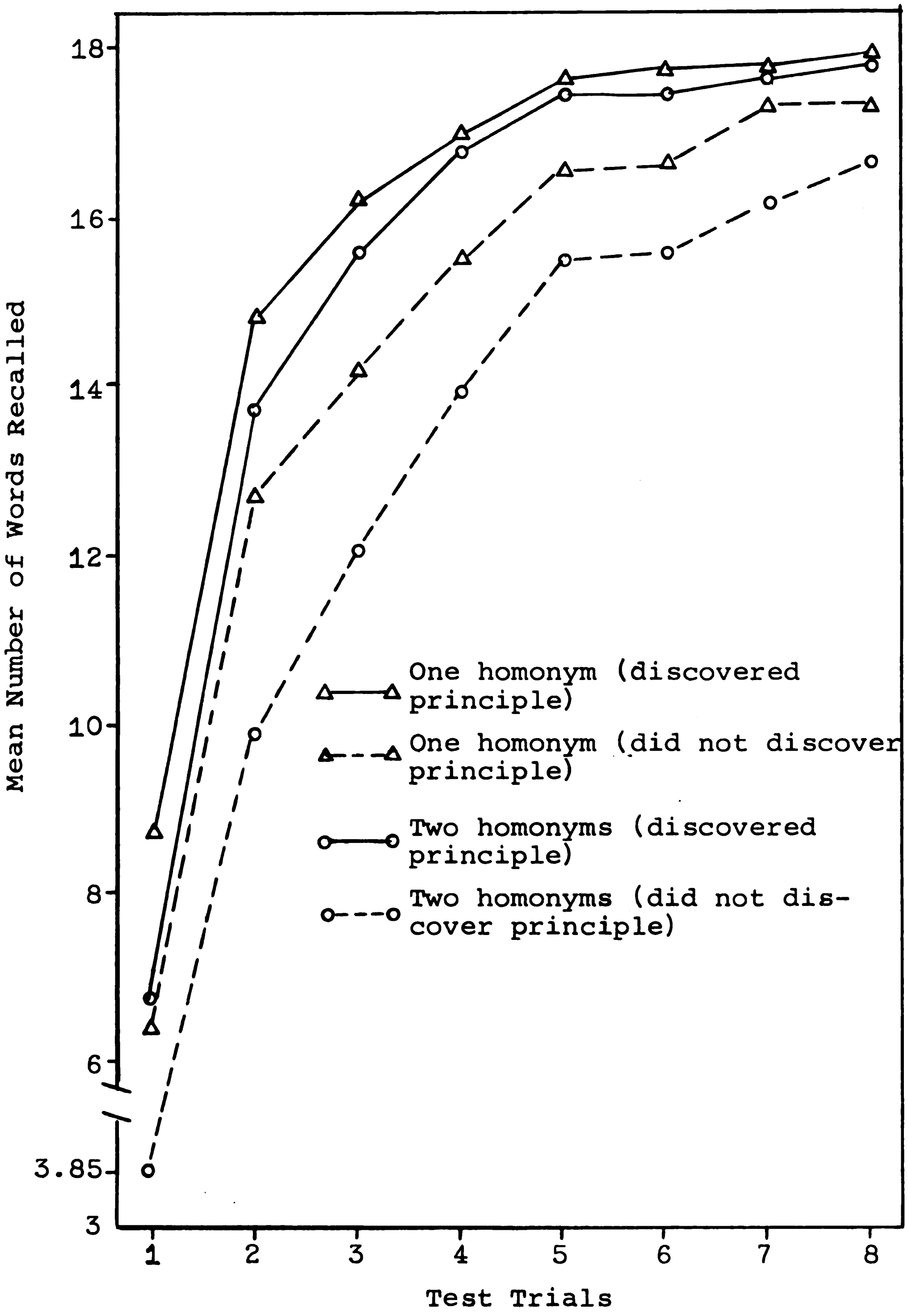

Figure 1. Mean number of words correctly recalled over eight test trials by Ss who either did, or did not, discover the principle (Experiment I).

these two lists.[21] Inspection of Figure 1 reveals that the performance of Ss who discovered the principle was clearly superior to the corresponding performance of Ss who did not discover the principle.

This superiority is also apparent in the scores of these two groups along other dependent variables of Experiment I. Table 4 on the following page presents the sample means and variances for the seven dependent variables of this experiment. Inspection of this table reveals that, without exception, the means are distributed in the predicted direction. Furthermore, scores of Ss who could not be classified, which are also presented in Table 4, generally support the assertion that exclusion of these Ss from the sample did not have a significant impact on the results. This follows from the fact that the performance of this group of Ss was usually somewhere between that of Ss who either did or did not discover the principle.

In view of these findings, a series of one-tailed t-tests were computed as tests of hypotheses one and two.[22] The results of these tests are also presented in Table 4. These

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[21]Because of these differences, this distinction shall be maintained throughout most subsequent analyses in this dissertation.

[22]There are two distinct formulas which may be used in computing the denominator of student's t-ratio. As a general rule of thumb, the author used the formula for unequal population variances whenever the ratio of the obtained sample variances exceeded two. Otherwise, the pooled estimate formula was used. This rule was followed throughout the dissertation.

Table 4. Tests of differences between the mean performance levels of Ss who either did, or did not, discover the principle at some point during Experiment I.

	N	Legend	Number trials to criterion	Total number correct	Number spelling distortions	Number improper plurals	Number extralist intrusions	Number intralist intrusions	Total number intrusions
A. One-Homonym Lists									
Ss who discovered the principle (D)	47	$\bar{x}$ s_x^2	5.49 3.12	127.87 63.03	1.26 2.36	0.68 0.70	1.60 4.99	1.26 2.76	4.89 17.88
Ss who did not discover the principle (ND)	58	$\bar{x}$ s_x^2	6.98 3.21	117.02 198.89	2.54 9.34	0.78 1.69	3.59 10.35	3.48 12.11	10.38 47.89
Ss who could not be classified (NC)	8	$\bar{x}$ s_x^2	6.50 3.14	122.38 98.55	3.25 6.79	1.50 2.86	2.13 1.84	3.88 8.98	10.75 32.21
t-tests (D vs. ND)			-4.27**	5.01**	2.78**	-.45	3.73**	4.10**	5.00**
B. Two-Homonym Lists									
Ss who discovered the principle (D)	47	$\bar{x}$ s_x^2	5.70 3.21	123.17 138.54	2.32 6.74	1.28 3.90	0.83 1.06	2.13 6.55	6.55 22.17
Ss who did not discover the principle (ND)	53	$\bar{x}$ s_x^2	7.81 2.43	103.49 401.33	4.17 9.99	0.87 1.85	3.30 12.64	6.26 48.28	14.60 89.21
Ss who could not be classified (NC)	5	$\bar{x}$ s_x^2	6.60 6.30	105.40 995.30	2.40 7.80	0.40 0.80	1.80 3.20	4.20 10.70	8.80 39.70
t-tests (D vs. ND)			-6.24**	6.07**	3.18**	-1.19	4.84**	4.04**	5.48**

$^{**}P < 0.01$.

tests indicate that the differences between means for Ss who either did or did not discover the principle are significant across all but one of the dependent variables ($P < 0.01$). The only exception occurred for the measure of number of improper plurals. Differences on this variable fell far short of significance. In view of these results, both corollaries of Hypothesis One as well as corollaries "a", "b", "c", and "e" of Hypothesis Two are <u>rejected</u> as stated in the null form ($P < 0.01$). Corollary 2d, on the other hand, must be <u>accepted</u> as stated in the null form.

Two of the above decisions must be regarded as tentative; namely, the decisions to reject corollaries 1a and 2a. Due to the extensive number of interpolations which were made in deriving a measure of trials to criterion, the decision to reject corollary 1a is based on the magnitude of the obtained differences, rather than on a strict statistical test. The decision to reject Corollary 2a is also tentative. When this analysis was repeated for classifications made by the independent judge, the difference between the mean number of spelling errors made by Ss who either did or did not discover the principle failed to reach a significant level for one-homonym lists (see Table 20 in Appendix C).[23]

Tests of Hypotheses Three and Four followed the same format as tests of Hypotheses One and Two. Means and variances

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[23]This was the only instance in which an analysis carried out for classifications made by the independent judge failed to confirm the corresponding analysis for classifications of the principle investigator!

for Ss who either did or did not discover the principle are depicted in Table 5 on the following page. Examination of this table reveals that, with one exception, the means are distributed in the predicted direction. The single exception was that Ss presented two-homonym lists who discovered the principle during the first learning trial made more spelling errors than Ss who did not discover the principle.

One-tailed t-tests were therefore computed to determine which of the obtained differences were significant. The results of these tests are also depicted in Table 5. Here there are decided differences between the results for Experiment I and those for Experiment II. In sharp contrast to Experiment I, differences along only one of the variables are significant for both one- and two-homonym lists; namely, number of words correctly recalled on the first test trial ($P < 0.01$). Differences along two other variables--number of improper plurals and number of intra-list intrusions--are significant for two-homonym lists ($P < 0.05$), but the corresponding differences on one-homonym lists are extremely small. This contrast raises the question of whether or not these apparently significant differences might not also have been due to chance. In general, therefore, it would appear that Ss who discovered the principle did not differ from Ss who did not discover the principle as far as the number of intrusions made on the first test trial is concerned.

Table 5. Tests of differences in the first test trial performance of Ss who either did or did not discover the principle during the first learning trial of Experiment II.

	N	Legend	Number correct (1st trial)	Number spelling distortions	Number improper plurals	Number extra-list intrusions	Number intra-list intrusions	Total number intrusions
A. One-Homonym Lists								
Ss who discovered the principle (D)	31	$\bar{x}$	9.32	0.53	0.16	1.42	1.13	3.06
		s_x^2	7.83	0.72	0.21	5.45	1.72	8.86
Ss who did not discover the principle (ND)	79	$\bar{x}$	7.47	0.61	0.15	2.09	1.18	3.87
		s_x^2	9.51	0.75	0.17	5.67	1.94	8.96
t-tests (D vs. ND)			2.91**	0.47	-0.10	1.33	0.17	1.28
B. Two-Homonym Lists								
Ss who discovered the principle (D)	24	$\bar{x}$	7.75	1.21	0.38	1.25	1.13	3.58
		s_x^2	9.51	0.87	0.51	3.15	1.33	6.43
Ss who did not discover the principle (ND)	98	$\bar{x}$	6.02	1.12	0.08	1.36	1.67	4.15
		s_x^2	10.68	1.22	0.07	2.99	3.17	7.31
t-tests (D vs. ND)			3.25**	-0.37	-1.98*	0.29	1.85*	1.00

* $P < 0.05$
** $P < 0.01$

These results therefore lead to the following decisions: Hypothesis Three is rejected as stated in the null form ($P < 0.01$). But Hypothesis Four must be accepted in toto, as stated in the null form.

The combined results of tests of Hypotheses One through Four lead to the following generalizations. It would appear that Ss who discover the principle during the first learning trial recall more words correctly than those who do not, as early as the first test trial. However, these Ss do not appear to make fewer intrusions in recall on this trial than Ss who do not discover the principle. Beyond this initial test trial, Ss who discover the principle apparently maintain their superior recall and also begin to make fewer intrusions than Ss who do not. These conclusions, which admittedly involve free generalization between Experiments I and II, will receive considerable attention in Chapter V of this dissertation.

III. Configural Perception and the Encoding Process

Hypotheses Five and Six predict that the per cent of Ss who discover the principle will be larger for lists containing positive perceptual cues than for lists which do not contain these cues.

Hypothesis 5: Positive perceptual cues will enhance the discovery of the principle as early as the first learning trial. The corollary hypotheses, stated in null form, are as follows:

<u>Corollary 5a</u>: The per cent of individuals who discover the principle during the first learning trial when presented lists with one homonym will be less than, or equal to, the per cent of individuals who discover the principle when presented lists with two homonyms.

<u>Corollary 5b</u>: The per cent of individuals who discover the principle during the first learning trial when presented lists in which the categorical terms are capitalized will be less than, or equal to, the per cent of individuals who discover the principle when presented lists in which the categorical terms are not capitalized.

<u>Corollary 5c</u>: The per cent of individuals who discover the principle during the first learning trial when presented lists in which the categorical terms are fixed in the first position will be less than, or equal to, the per cent of individuals who discover the principle when presented lists in which the categorical terms are not fixed in the first position.

Data from Experiment II were used to test Hypothesis Five. All Ss in this experiment completed the level of principle formation questionnaire immediately after the first test trial. Thus, responses to this form should determine whether or not a given S discovered the principle during the first learning trial.

<u>Hypothesis 6</u>: Positive perceptual cues will enhance the discovery of the underlying principle throughout the learning task. The corollary hypotheses, <u>stated in null form</u>, are as follows:

<u>Corollary 6a</u>: The per cent of individuals who discover the principle at some point during the learning task when presented lists with one homonym will be less than, or equal to, the per cent of individuals who discover the principle when presented lists with two homonyms.

<u>Corollary 6b</u>: The per cent of individuals who discover the principle at some point during the learning task when presented lists in which the categorical terms are capitalized will be less than, or equal to, the per cent of individuals who discover the principle when presented lists in which the categorical terms are not capitalized.

> <u>Corollary 6c</u>: The per cent of individuals who discover the principle at some point during the learning task when presented lists in which the categorical terms are fixed in the first position will be less than, or equal to, the per cent of individuals who discover the principle when presented lists in which the categorical terms are not fixed in the first position.

Data from Experiment I were used to test Hypothesis Six. Ss in this experiment completed the level of principle formation questionnaire immediately after they reached criterion, or after the eighth test trial, whichever came first. Therefore, responses to the questionnaire should determine whether or not a given S discovered the principle at some point during the learning task.

The per cent of Ss who discovered the principle during the first learning trial of Experiment II is depicted in Column I of Table 6 on the following page. The per cent of Ss who discovered the principle at some point during Experiment I is shown in column II of the same table. In general, the per cents are distributed in the predicted direction for all three independent variables.

A one-tailed test of difference in per cent was therefore computed to determine whether or not the obtained differences were statistically significant. This test, which is described by Garrett (1958), is based on the central limit theorem, i.e., the binomial distribution closely approximates the normal distribution for large values of N. Thus, the "Z" which is obtained from a given test, represents the number of standard deviations an obtained difference in

Table 6. Per cent of Ss who discovered the principle during the first learning trial of Experiment II (column I) or at some point during the eight learning trials of Experiment II (column II) when presented lists with varying perceptual cues.

	Experiment II: First Test Trial	Experiment I: Test Trials 1-8
Ss presented lists with <u>one homonym</u>	28.18% (N = 110)	44.76% (N = 105)
Ss presented lists with <u>two homonyms</u>	19.51% (N = 123)	47.00% (N = 100)
Z-tests	1.56	negative value
Ss presented lists in which the categorical term is <u>capitalized</u>	28.44% (N = 109)	50.96% (N = 104)
Ss presented lists in which the categorical term is <u>not capitalized</u>	19.36% (N = 124)	40.59% (N = 101)
Z-tests	1.63	1.51
Ss presented lists in which the categorical term is <u>fixed</u> in first position	23.48% (N = 115)	49.51% (N = 101)
Ss presented lists in which the categorical term is <u>not fixed</u> in first position	23.73% (N = 118)	42.31% (N = 104)
Z-tests	negative value	1.04

Value needed for significance = 1.645 (alpha = 0.05) per cent falls above or below the hypothesized difference of zero per cent. The obtained "Z's" are also depicted in Table 6.

In order to be significant at the 0.05 level, the "Z" resulting from this test must be equal to, or greater than, 1.645. Although none of the obtained "Z's" exceeded 1.645, the results of three tests were extremely close to this value. Differences between Ss presented lists in which the categorical terms were either capitalized or not capitalized approached significance in both Experiment I and Experiment II. The same is true of the difference between Ss presented one and two homonym lists during the single learning trial of Experiment II.

However, since none of the obtained "Z's" exceeded 1.645, Hypotheses Five and Six must be accepted as stated in the null form. Despite this decision, the three differences which approached significance will receive further consideration in Chapter V.

Hypotheses Seven through Ten predict that the performance of Ss presented lists with positive perceptual cues will be superior to the corresponding performance of Ss presented lists which lack these cues. These predictions are based on the logical combination of the hypotheses which have thus far been considered. Hypotheses Five and Six, for example, predict that a greater number of Ss will discover the principle when presented lists with positive perceptual cues than when presented lists which lack these cues. This prediction, therefore, takes the form of an "if A, then B" premise. According to hypotheses one through four, discovery of the principle should, in turn, result in improved performance. This prediction, therefore, takes the form of an "if B, then C" premise. Since hypotheses seven through ten predict that the performance of Ss presented lists with positive perceptual cues will be superior to the corresponding performance of Ss presented lists which lack these cues, these hypotheses represent the deductive conclusion to the above premises; namely, "A, therefore C".

The validity of this conclusion was examined for the following four dependent variables: number of words recalled on the first test trial (Hypothesis 7), number of trials to criterion (Hypothesis 8), total number of intrusions (Hypothesis 9), and total number of words recalled over all eight test trials (Hypothesis 10).

<u>Hypothesis 7</u>: Because of their effect on the formation of principles, positive perceptual cues will aid in the formation of associations as early as the first learning trial. The corollary hypotheses, <u>stated in null form</u>, are as follows:

<u>Corollary 7a</u>: The mean number of words correctly recalled on the first test trial by Ss presented lists with one homonym will be less than, or equal to, the corresponding mean for Ss presented lists with two homonyms.

<u>Corollary 7b</u>: The mean number of words correctly recalled on the first test trial by Ss presented lists in which the categorical terms are capitalized will be less than, or equal to, the

corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

Corollary 7c: The mean number of words correctly recalled on the first test trial by Ss presented lists in which the categorical terms are fixed in the first position will be less than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

Hypothesis 8: Because of their effect on the discovery of the relevant principle, lists containing positive perceptual cues will be learned more rapidly than lists which lack these cues. The corollary hypotheses, stated in null form, are as follows:

Corollary 8a: The mean number of trials to criterion for Ss presented lists with one homonym will be greater than, or equal to, the corresponding mean for Ss presented lists with two homonyms.

Corollary 8b: The mean number of trials to criterion for Ss presented lists in which the categorical terms are capitalized will be greater than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

Corollary 8c: The mean number of trials to criterion for Ss presented lists in which the categorical terms are fixed in the first position will be greater than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

Hypothesis 9: Because of their effect on the discovery of the relevant principle, lists with positive perceptual cues will elicit fewer intrusions in recall than lists which lack these cues. The three corollary hypotheses, stated in null form, are as follows:

Corollary 9a: The mean total number of intrusions made by Ss presented lists with one homonym will be greater than, or equal to, the corresponding mean for Ss presented lists with two homonyms.

Corollary 9b: The mean total number of intrusions made by Ss presented lists in which the categorical terms are capitalized will be greater than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

Corollary 9c: The mean total number of intrusions made by Ss presented lists in which the categorical terms are fixed in the first position will be greater than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

Hypothesis 10: Because of their effect on the formation of principles, positive perceptual cues will enhance the formation of verbal associations throughout the learning task. The corollary hypotheses, stated in null form, are as follows:

Corollary 10a: The mean total number of words recalled by Ss presented lists with one homonym will be less than, or equal to, the corresponding mean for Ss presented lists with two homonyms.

Corollary 10b: The mean total number of words recalled by Ss presented lists in which the categorical terms are capitalized will be less than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not capitalized.

Corollary 10c: The mean total number of words recalled by Ss presented lists in which the categorical terms are fixed in the first position will be less than, or equal to, the corresponding mean for Ss presented lists in which the categorical terms are not fixed in the first position.

The tests of hypotheses seven, eight, and nine followed approximately the same format. In each case, means for the relevant dependent variable were computed for each condition along the independent or treatment variables. These means--number of words recalled on the first test trial; number of trials to criterion; and, total number of intrusions--are shown in Column II of Tables 7, 8, and 9, respectively. As an examination of Table 7 reveals, the number of words recalled on the first test trial was determined for both Experiment I and Experiment II.[24]

Examination of Tables 7, 8, and 9 reveals that, without exception, the obtained means in Experiment I were distributed

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[24]Although this would appear to represent a replication of the test of Hypothesis 7, the difference in directions for these two experiments suggests that this analysis might better be viewed as a repeated test under two distinct test conditions.

Table 7. A 2x2x2, fixed-effects, analysis of variance test of the number of words correctly recalled on the first test trial by Ss presented lists with varying perceptual cues.

Source	Sample Means	d.f.	M.S.	F-ratios
A. First Test Trial of Experiment I				
One vs. Two Homonyms (H)	7.43 vs. 4.85	1	292.78	29.92**
Caps vs. No Caps (C)	6.53 vs. 5.75	1	27.05	2.77
Fixed vs. Random Position (P)	6.42 vs. 5.86	1	13.64	1.39
Interactions:				
H x C		1	6.96	0.71
H x P		1	1.64	0.17
C x P		1	0.96	0.10
H x C x P		1	22.55	2.31
Within		168	9.78	
Total		175		
B. First Test Trial of Experiment II				
One vs. Two Homonyms (H)	7.78 vs. 6.29	1	115.50	11.89**
Caps vs. No Caps (C)	6.84 vs. 7.23	1	8.08	0.83
Fixed vs. Random Position (P)	6.92 vs. 7.14	1	2.54	0.26
Interactions:				
H x C		1	8.08	0.83
H x P		1	28.50	2.94
C x P		1	0.04	0.00
H x C x P		1	3.50	0.36
Within		200	9.71	
Total		207		

$^{**}P \leq 0.01$

Table 8. A 2x2x2 fixed effects analysis of variance test of the number of trials taken to reach criterion by Ss presented lists with varying perceptual cues (Experiment I).

Source	Means	d.f.	M.S.	F-ratio
One vs. Two Homonyms (H)	6.27 vs. 7.00	1	23.27	6.13**
Caps vs. No Caps (C)	6.41 vs. 6.86	1	9.09	2.39
Fixed vs. Random Position (P)	6.61 vs. 6.66	1	0.10	0.02
Interactions:				
H x C		1	13.10	3.45
H x P		1	2.27	0.60
C x P		1	2.27	0.60
H x C x P		1	2.27	0.60
Within		168	3.80	
Total		175		

$^{**}P < 0.01$

Table 9. A 2x2x2 fixed effects analysis of variance test of the total number of intrusions made by Ss presented lists with varying perceptual cues (Experiment I).

Source	Means	d.f.	M.S.	F-ratio
One vs. Two Homonyms (H)	7.69 vs. 11.57	1	660.69	11.21**
Caps vs. No Caps (C)	9.35 vs. 9.91	1	13.64	0.23
Fixed vs. Random Position (P)	9.63 vs. 9.64	1	0.006	0.00
Interactions:				
H x C	(See table 10 on page 85)	1	448.64	7.61**
H x P		1	25.51	0.43
C x P		1	174.00	2.95
H x C x P		1	45.00	0.76
Within		168	58.95	
Total		175		

$^{**}P < 0.01$

in the predicted direction. Regardless of the dependent variable on which performance was determined, Ss presented lists with one homonym, capitalized categorical terms, or the categorical terms in a fixed position, outperformed Ss presented lists which lacked these cues. Examination of "Part B" of Table 7, on the other hand, reveals that differences in the mean number of words recalled on the first test trial of Experiment II were distributed in the predicted direction for only one of the three independent variables; namely, the difference between Ss presented one and two homonym lists.

Despite this apparent conflict between the results of Experiment I and Experiment II, a 2x2x2 fixed effects analysis of variance was computed for each dependent variable. Prior to this computation the sample size in each of the eight cells was equated by randomly eliminating Ss from the sample. In Experiment I the cell sample was equated at 22, while in Experiment II the "n" in each cell was set equal to 26. The advantage of equating the number of Ss in each cell over computations involving unequal "n's" rests not only in greater ease of computation, but in greater robustness to violations in the assumption of homogeneity of variance as well (Guenther, 1964).

Following this adjustment, the analysis of variance tests were computed. Mean square variances and F-ratios resulting from these tests are also depicted in Tables 7, 8, and 9. The results of these tests are remarkably consistent across all three dependent variables. In each case, the difference in performance between Ss presented lists with either one or two homonyms was statistically significant ($P < 0.01$). Differences along the other two independent variables, on the other hand, were not statistically significant. In most cases, these differences did not even approach significance.

Only one other result reached a statistically significant level; namely, the interaction between number of homonyms and capitalization of the categorical terms when total number of intrusions served as the dependent variable. Means for the four conditions in this interaction are shown in Part "A" of Table 10 on the following page. Examination of this table reveals that capitalizing the categorical terms reduces the number of intrusions on one-homonym lists, but slightly increases the number of intrusions on two-homonym lists.

The corresponding interaction for various other dependent variables is also shown in Table 10. Although the interaction on these measures fails to reach significance when alpha is equal to 0.05, each distribution suggests that capitalizing the categorical terms has a greater impact on one-homonym than on two-homonym lists. Further, many of these interactions approach statistical significance.

The only evidence which runs counter to the above was obtained for number of words correctly recalled on the first test trial of Experiment II. Here, differences were somewhat larger for two-homonym than for one-homonym lists. But this

Table 10. Distribution of means in the interaction between number of homonyms and capitalization of the categorical term.

Table 10. Distribution of means in the interaction between number of homonyms and capitalization of the categorical term.

(A) Total number intrusions:

	One Homonym	Two Homonyms
Caps	5.82	12.89
No Caps	9.57	10.25
F-ratio	7.61	

(B) Total number correct:

	One Homonym	Two Homonyms
Caps	126.02	110.06
No Caps	118.75	111.27
F-ratio	2.82	

(C) Trials to criterion:

	One Homonym	Two Homonyms
Caps	5.77	7.05
No Caps	6.77	6.96
F-ratio	3.45	

(D) Per cent discovering principle during first learning trial (Experiment II)

	One Homonym	Two Homonyms
Caps	34.0%	23.2%
No Caps	22.8%	16.4%

(E) Per cent discovering principle during learning trials 1-8 (Experiment I)

	One Homonym	Two Homonyms
Caps	54.9%	47.2%
No Caps	35.2%	46.8%

finding presents an interesting contrast to the per cent of Ss who discovered the principle during the first learning trial of this same experiment (depicted in Table 10 above). In short, the overwhelming majority of evidence supports the assertion that the effect of capitalizing the categorical terms is more pronounced on one-homonyms lists than on two-homonym lists. This finding will therefore receive further consideration in Chapter V.

The results of the four analysis of variance tests depicted in Tables 7, 8, and 9 above, lead to the following decisions. Corollaries 6a, 7a, and 8a, are all <u>rejected</u> when stated in the null form ($P < 0.01$). Regardless of which dependent variable is considered, the performance of Ss presented one-homonym lists appears to be superior to the corresponding performance of Ss presented two-homonym lists. Corollaries "b" and "c" of hypotheses six, seven, and eight, on the other hand, must all be <u>accepted</u> as stated in the null form. Regardless of which dependent variable is considered, the performance of Ss presented lists in which the categorical terms are fixed in the first position does not appear to differ from the corresponding performance of Ss presented lists in which the position of the categorical terms is varied from triad to triad. Further, if capitalizing the categorical term does have any impact on performance, this effect is probably limited to one-homonym lists.

The test of hypothesis ten was somewhat more elaborate than that of hypotheses seven through nine. The decision to use a different analysis stemmed from the author's inspection of the learning curves for each of the list conditions where number of words correctly recalled served as the dependent variable. These curves, which are depicted in Figure 2 on the following page, reveal that differences between the two conditions on each treatment variable are larger on the first two test trials than on any subsequent trials. In view of these observations, it seemed desirable to determine whether or not the interactions between test trials and any of the independent variables were significant. The existence of a significant interaction would, in turn, suggest that the effect of the relevant variable was dependent upon the particular test trial on which retention was determined.

These considerations led the author to select a four-way analysis of variance test, with test trials 1-8 serving as the fourth variable. However, the inclusion of the test trials variable gives rise to an important methodological consideration. Simply stated, observations on this variable are not independent, i.e., scores for any two trials are based on the same group of individuals. Including this variable in the analysis therefore violates the assumption of independent observations which underlies any analysis of variance test.

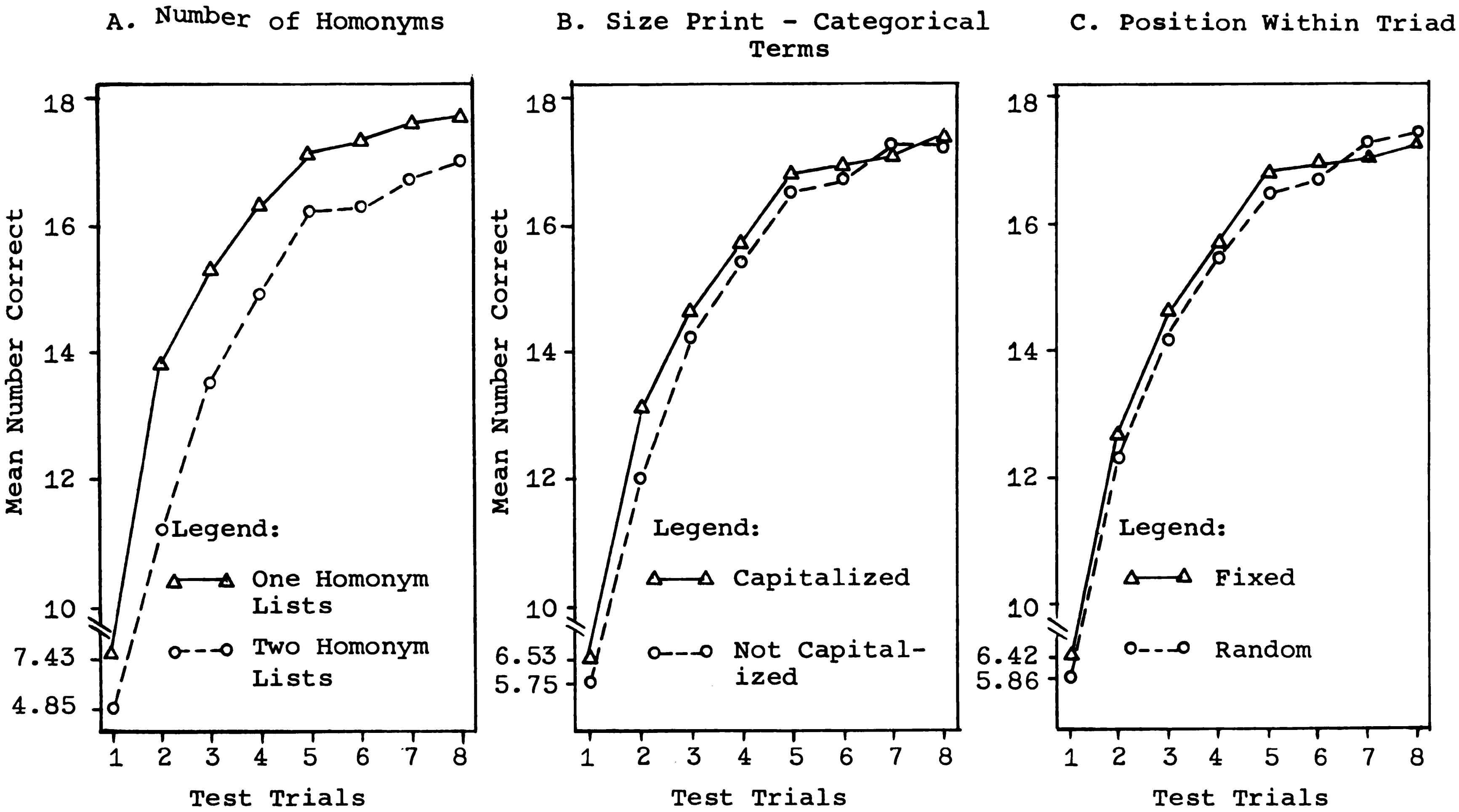

Figure 2. Learning curves (number of words correctly recalled) for Ss presented lists with varying perceptual cues (Experiment I).

Fortunately, Geiser and Greenhouse (1958) have described a computational procedure which takes full account of this violation of the assumption of independence. This procedure involves partitioning the within variance into two components--a within groups variance and a treatments x individuals within groups variance. The within groups variance is a pooled estimate of the variance of observations about the independent treatment means, while the treatments x individuals within groups variance is a pooled estimate of the variance of observations about the correlated treatment means. Thus, the within groups variance is used in the denominator of F-ratios for tests of differences between independent means while the treatments x individuals within groups variance is used in the denominator of F-ratios for tests of differences between correlated means.

But this computational revision does not fully account for the correlations which exist among observations whenever repeated measurements are made on the same group of individuals. As Geiser and Greenhouse (1958) point out, these correlations must fall somewhere between zero and one. If the correlations are zero, the observations are independent and the analysis of variance test is appropriate. But if the correlations are equal to one, it is possible to generate the complete set of observations from knowledge of observations on only one condition of the variable, thereby reducing the degrees of freedom to one.

In view of these considerations, Geiser and Greenhouse suggest that two tests should be used for every analysis based on non-independent observations--a liberal test in which the obtained F-ratios are compared with values needed for significance when the degrees of freedom in the numerator are set equal to K-1, and a conservative test in which the obtained F-ratios are compared with values needed for significance when the degrees of freedom in the numerator are reduced to one. If the F-ratios exceed the conservative value, one may safely conclude that the means are significantly different. But if the F-ratios do not exceed the liberal value, one must conclude that the means are not significantly different.

In view of these considerations, a 2x2x2x8 fixed effects analysis of variance test was computed using the revisions suggested by Geiser and Greenhouse. As in preceding analyses, the sample size was reduced to 22 in each cell prior to the computation. The results of this analysis are presented in Table 11 on the following page. F-ratios for interactions between trials and the three perceptual cues were subjected to both the liberal and conservative tests. Results of these comparisons are also shown in Table 11.

An examination of Table 11 reveals that two of the interactions are significant--trials x number of homonyms ($P < 0.01$--conservative test), and trials x capitalization of the categorical terms ($P < 0.05$--liberal test). The distribution of

Table 11. Results of a 2x2x2x8 analysis of variance test of the total number of words recalled by Ss presented lists with varying perceptual cues. Revisions in computation based on Geiser and Greenhouse (1958).

Source	Sample Means	d.f.	Mean Square	F-ratio
One vs. Two Homonyms (H)	122.42 vs. 110.67	1	759.34	22.01**
Caps vs. No Caps (C)	118.05 vs. 115.05	1	49.50	1.44
Fixed vs. Random Position (P)	117.38 vs. 115.72	1	15.14	0.44
Interactions:				
H x C		1	97.23	2.82
H x P		1	0.01	0.003
C x P		1	68.25	1.98
H x C x P		1	39.56	1.15
With Groups		168	34.50	
Trials (T)		7	2512.23	840.21**
Interactions:				
H x T		7	25.65	8.58**
T x C		7	6.88	2.30*
P x T		7	3.33	1.12
H x C x T		7	2.57	0.86
H x P x T		7	4.79	1.60
C x P x T		7	3.04	1.02
H x C x T		7	2.46	0.82
Treatments x Individuals within groups		1176	2.99	
Total		1407		

**P $<$ 0.01 Conservative Test
*P $<$ 0.05 Liberal Test

means in these two interactions is represented by learning curves "A" and "B" in Figure 2 above. Although the interactions may be in large part attributed to decreases in the differences between the two conditions as the Ss approach the low-ceiling in the task, these differences also display some variability across the first three test trials where the low-ceiling effect is not pronounced.

Differences between Ss presented either one- or two-homonym lists, for example, are fairly constant across the first two test trials, but show some decrease on the third test trial. Differences between Ss presented lists in which the categorical term is either capitalized or not capitalized, on the other hand, reach an asymtote on test trial two, and then decrease dramatically on test trial three. These results suggest that the effect of the two relevant treatments is sizable across the first two test trials, but is then counteracted by the low-ceiling effect during test trials three through eight. The results also suggest that the author should have focused his analysis on the second test trial where differences reached a peak, rather than during the first test trial where they had not yet reached this level.

Regarding the effects of the three treatment variables, the results of this test are highly consistent with those obtained in tests of Hypotheses seven through nine. Once again, the means for the three treatments fall in the predicted direction, but only the difference between one- and two-homonym lists is significant ($P < 0.01$). The only other result which approaches statistical significance is that obtained for the interaction between number of homonyms and capitalization of the categorical terms. The distribution of means in this interaction, which are presented in Table 10 above, suggests that the effect of capitalizing the categorical terms is more pronounced for one-homonym than for two-homonym lists.

Because the F-ratios obtained in the above test are algebraically equivalent to those obtained in a standard, three-way analysis of variance test of the total number of words recalled over all eight test trials, it is possible to use these results to make the following decisions regarding hypothesis ten. Corollary 10a is the only corollary which should be rejected as stated in the null form ($P < 0.01$). Corollaries 10b and 10c must be accepted as stated in the null form. The inferences which may be made from this test are therefore identical to those of hypotheses seven through nine.

Further Analysis of the Effect of Configural Perception on the Derivation of Higher-Order Coding Schemes

Three variables have been shown to affect the short-term retention of a given S in this study--whether or not he discovered the relevant principle; whether he was presented a list with one-homonym or a list with two-homonyms; and, whether he received a list in which the categorical terms were capitalized or a list in which these terms were not capitalized. In an attempt to determine the basic source of these effects, the author undertook the following exploratory analysis.

First, each correct response over the first three test trials was identified by type--categorical, misspelled exemplar, or exemplar.[25] The first three test trials were selected for this analysis because differences in recall were largest on these trials, and, because all three stimulus lists had been presented by this point in the task. "Type of response" was then treated as an independent variable in a four-way analysis of variance test. The three variables listed above constituted the other three treatments in this analysis. By examining the interactions between "type of response" and each treatment it is possible to gain some insight into the source of the obtained differences in performance between the two conditions on each variable.

Suppose, for example, that there is a significant interaction between "type of response" and discovery of the principle. Further suppose that the distribution of means in this interaction suggests that differences between Ss who either did or did not discover the principle were small for both exemplar and misspelled exemplar terms, but were quite large for categorical terms. This would suggest that the categorical terms play a critical role in the discovery of the

[25]See Table 1 in Chapter III for the meaning of these three types of response.

principle. This, in turn, would explain why capitalizing the categorical terms increased retention; namely, differential attention to the categorical terms resulting from capitalizing these terms resulted in an increased likelihood of discovering the principle.

In contrast to this explanation, suppose that the interaction between "type of response" and capitalization of the categorical terms is significant. Further suppose that the distribution of means in this interaction suggests that differences between Ss presented lists in which the categorical terms are either capitalized or not capitalized are large for categorical terms, but are small for exemplar and misspelled-exemplar terms. This result would suggest that the differential recall between these two groups stemmed from simple differences in the recall of the categorical terms and not from differences in the likelihood of discovering the principle as the above example suggests. In short, it should be possible to test several potential explanations of the effect of each of the three treatment variables by examining the interactions between "type of response" and each treatment.

A 2x2x2x3 analysis of variance test was therefore computed with "type of response" as the fourth independent variable. The dependent variable in this analysis was number of words correctly recalled over the first three test trials. Since observations on the "type of response" variable are based on the same group of Ss, the modifications suggested by Geiser and Greenhouse (1958) were adopted. By randomly eliminating Ss from the sample, the "n" in each cell was equated at nineteen. This had the further effect of equating the number of Ss who discovered the principle for the two conditions on both list variables.

The results of this analysis are presented in Table 12 on the following page. The first finding of some importance is that the difference between Ss presented either one- or two-homonym lists remains significant despite the fact that, in this analysis, the per cent of Ss who discovered the principle was equal for these two groups ($P < 0.01$). Differences between Ss presented lists in which the categorical terms were either capitalized or not capitalized, on the other hand, were severely reduced by these conditions.
A serendipidous finding was the significant interaction between discovery of the principle and number of homonyms ($P < 0.01$). Reexamination of Figure 2 in Section II of this Chapter reveals that discovery of the principle is more beneficial to Ss presented lists with two homonyms than to Ss presented lists with one homonym. Differences in the mean number of words correctly recalled over the first three test trials were 1.69 and 3.16 for one- and two-homonym lists, respectively.

But the interactions between "type of response" and each of the three treatments failed to even approach significance. Although this result was greeted with initial disappointment,

Table 12. Results of a 2x2x2x3 fixed-effects analysis of variance test of the number of words recalled over the first three test trials of Experiment I, with "type of response" as the fourth variable.

Source	Sample Means	d.f.	Mean Square	F-ratio
Principle vs. Not Principle (P)	37.47 vs. 30.18	1	670.63	89.52**
One vs. Two Homonyms (H)	36.66 vs. 30.99	1	411.16	54.89**
Caps vs. No Caps (C)	34.41 vs. 33.24	1	17.37	2.32
Interactions:				
P x H		1	61.16	8.16**
P x C		1	1.84	0.35
H x C		1	25.11	3.35
P x H x C		1	18.16	2.42
Within Groups		144	7.49	
Type of Response (R):		2	6.12	0.68
categorical	33.84			
exemplar	33.21			
misspelled exemplar	34.41			
Interactions:				
P x R		2	1.23	0.14
H x R		2	1.48	0.17
C x R		2	2.90	0.32
P x H x R		2	0.29	0.03
P x C x R		2	5.82	0.65
H x C x R		2	0.02	0.00
P x H x C x R		2	2.02	0.23
Treatments x Individuals Within Groups		288	8.95	
Total		455		

**P $<$ 0.01

it was nevertheless useful in eliminating several potential explanations of the effects of the three treatment variables. These results will therefore receive considerable attention in Chapter V.

In view of this failure to obtain significant interactions, the author decided to analyze correct responses in still another way. Each correct response over the first three test trials was classified by the "type of association" involved: categorical-exemplar; categorical-misspelled exemplar; and, exemplar-misspelled exemplar. Categorical-exemplar associations, for example, involved giving an exemplar term as a response to a categorical stimulus or vice-versa. The other two types of association were identified in an analogous manner. "Type of association" was then treated as the fourth variable in a repetition of the 2x2x2x3 analysis of variance test presented above.

The results of this test are presented in Table 13 on the following page. Once again, the interactions failed to approach statistical significance. Although this result is somewhat discouraging, the test was nevertheless useful in eliminating other potential explanations of the effect of the three treatment variables. Therefore, this analysis will also be considered in more detail in Chapter V.

Table 13. Results of a 2x2x2x3 fixed-effects analysis of variance test of the number of words recalled over the first three test trials of Experiment I, with "type of association" as the fourth independent variable.

Source	Sample Means	d.f.	Mean Square	F-ratio
Principle vs. Not Principle(P)	37.47 vs. 30.18	1	670.63	89.52**
One vs. Two Homonyms (H)	36.66 vs. 30.99	1	411.16	54.89**
Caps vs. No Caps (C)	34.41 vs. 33.24	1	17.37	2.32
Interactions:				
P x H		1	61.16	8.16**
C x P		1	1.84	0.35
H x C		1	25.11	3.35
P x H x C		1	18.16	2.42
Within Groups		144	7.49	
Type of Association (A):		2	18.20	2.18
categorical-exemplar	34.08			
categorical-misspelled exemplar	34.71			
exemplar-misspelled exemplar	32.70			
Interactions:				
P x A		2	0.09	0.01
H x A		2	5.95	0.71
C x A		2	3.03	0.36
P x H x A		2	2.92	0.35
P x C x A		2	2.27	0.27
H x C x A		2	1.78	0.21
P x H x C x A		2	8.35	
Treatments x Individuals Within Groups		288	8.35	
Total		455		

$^{**}P < 0.01$

IV. Higher-Order Coding Schemes and Long-Term Retention

Exactly three weeks after the initial learning session, Ss in Experiment I were presented with a single test trial. Measures of performance on this trial were used to test Hypotheses Eleven through Fourteen. With the exception of Hypothesis Fourteen (which will be considered in more detail later in this section), this set of hypotheses predicts that long-term retention will be influenced by the same variables that affect short-term retention.

Hypothesis 11 (stated in null form): The mean number of words correctly recalled on the test of long-term retention by Ss who discovered the principle during acquisition will be less than or equal to the mean number of words recalled by Ss who did not discover the principle.

Hypothesis 12: With one exception, the number of intrusions made on the test of long-term retention will be lower for those Ss who discovered the principle during acquisition than for those Ss who did not discover the principle. The single exception is number of improper plurals, where the opposite prediction is made. The corollary hypotheses, stated in null form, are as follows:

Corollary 12a: The mean number of spelling distortions made by Ss who have discovered the principle during acquisition will be greater than, or equal to, the mean number of spelling distortions made by Ss who have not discovered the principle.

Corollary 12b: The mean number of extra-list intrusions made by Ss who have discovered the principle during acquisition will be greater than, or equal to, the mean number of extra-list intrusions made by Ss who have not discovered the principle.

Corollary 12c: The mean number of intra-list intrusions made by Ss who have discovered the principle will be greater than, or equal to, the mean number of intra-list intrusions made by Ss who have not discovered the principle.

<u>Corollary 12d</u>: The mean number of improper plurals formed by Ss who have discovered the principle during acquisition will be less than, or equal to, the mean number of improper plurals formed by Ss who have not discovered the principle.

<u>Corollary 12e</u>: The mean total number of intrusions formed by Ss who have discovered the principle during acquisition will be greater than, or equal to, the mean total number of intrusions made by Ss who have not discovered the principle.

<u>Hypothesis 13</u>: Because of their effect on the discovery of the principle, "positive" conditions on each of three perceptual variables will aid in long-term retention. The three corollary hypotheses, <u>stated in the null form</u>, are as follows:

<u>Corollary 13a</u>: The mean number of words correctly recalled on the test for long-term retention by Ss presented lists with one homonym will be less than, or equal to, the mean number of words recalled on this test by Ss presented lists with two homonyms.

<u>Corollary 13b</u>: The mean number of words correctly recalled on the test of long-term retention by Ss presented lists in which the categorical terms are capitalized will be less than, or equal to, the mean number of words recalled on this test by Ss presented lists in which the categorical terms are not capitalized.

<u>Corollary 13c</u>: The mean number of words correctly recalled on the test for long-term retention by Ss presented lists in which the categorical terms are fixed in the first position will be less than, or equal to, the mean number of words recalled on this test by Ss presented lists in which the categorical terms are not fixed in the first position.

Tests of Hypotheses Eleven through Thirteen followed the same format as the corresponding tests of short-term retention. However, the sample was slightly modified for the analysis of long-term retention. In order to control for differences in the initial level of acquisition, only those Ss who reached criterion were included in this analysis.

Sample means and variances were computed for each dependent variable in Hypotheses Eleven and Twelve. These values are depicted in Table 14 on the following page. Inspection of this table reveals that, with the exception of number of improper plurals on one-homonym lists, the means are distributed in the predicted direction across the six dependent variables.

One-tailed t-tests were therefore computed to determine whether or not the obtained differences were statistically significant. The results, which are also shown in Table 14, reveal that none of the differences even approach statistical significance. In view of these findings, Hypotheses Eleven and Twelve must be accepted as stated in the null form. The performance of Ss who have discovered the principle during acquisition does not appear to differ from the corresponding performance of Ss who have not discovered the principle.

The test of Hypothesis Thirteen also followed the same format as earlier tests of the effect of list variables. The mean number of words recalled for each condition on the three independent variables is shown in Part "A" of Table 15 on page 104. With the exception of the "position within each triad" variable, these means are distributed in the opposite direction from that predicted. Therefore, the null statement of Corollaries 13a and 13b must be accepted without any further analysis.

Part "B" of Table 15 depicts the mean total number of intrusions for each condition on the three treatment variables. Due to certain theoretical considerations advanced in the

Table 14. Mean performance levels on the test of long-term retention for those Ss who either did or did not discover the principle during acquisition.

	N	Legend	Number words recalled	Number spell-ing distorsions	Number improper plurals	Number extra-list intrusions	Number intra-list intrusions	Total number intrusions
A. <u>One-Homonym Lists</u>								
Ss who discovered principle (D)	34	$\bar{x}$	11.24	1.15	0.29	1.74	0.15	3.32
		s_x^2	7.53	0.92	0.27	2.38	0.19	4.41
Ss who did not discover principle (ND)	33	$\bar{x}$	10.88	1.21	0.30	2.06	0.39	3.97
		s_x^2	8.14	0.98	0.22	2.93	0.93	6.97
Ss who could not be classified (NC)	7	$\bar{x}$	9.57	1.57	0.43	1.86	0.71	4.57
		s_x^2	3.62	2.95	0.29	2.14	0.57	6.48
t-tests (D vs ND)			0.83	0.27	0.07	0.82	1.34	1.11
B. <u>Two-Homonym Lists</u>								
Ss who discovered principle (D)	39	$\bar{x}$	11.77	1.46	0.21	0.56	0.13	2.36
		s_x^2	13.13	2.20	0.48	0.73	0.11	4.18
Ss who did not discover principle (ND)	20	$\bar{x}$	11.05	1.80	0.15	0.90	0.30	3.15
		s_x^2	9.31	3.54	0.13	1.57	0.43	7.61
Ss who could not be classified (ND)	3	$\bar{x}$	12.67	1.67	0.00	2.00	0.33	4.00
		s_x^2	6.33	2.33	0.00	7.00	0.33	13.00
t-tests (D vs. ND)			0.80	0.70	-0.40	1.00	1.10	1.25

Table 15. Results of an analysis of variance test of performance on the test for long-term retention of Ss presented lists with varying perceptual cues.

Source	Sample Means	d.f.	Mean Square	F-ratios
A. Number of Words Correctly Recalled				
One vs. Two Homonyms (H)	11.71 vs. 11.67	1	24.04	2.44
Caps vs. No Caps (C)	11.02 vs. 11.37	1	3.12	0.32
Fixed vs. Random Position (P)	11.62 vs. 10.77	1	18.62	1.90
Interactions:				
H x C		1	12.46	2.27
H x P		1	0.96	0.10
C x P		1	6.50	0.66
H x C x P		1	5.54	0.56
Within		96	9.84	
Total		103		
B. Total Number of Intrusions				
One vs. Two Homonyms (H)	3.71 vs. 2.61	1	29.09	4.99*
Caps vs. No Caps (C)	2.98 vs. 3.38	1	4.43	< 1.00
Fixed vs. Random Position (P)	2.90 vs. 3.46	1	8.09	1.39
Interactions:				
H x C		1	0.24	< 1.00
H x P		1	2.78	< 1.00
C x P		1	6.01	1.03
H x C x P		1	9.05	1.55
Within		96	5.83	
Total		103		

*$P < 0.05$

following discussion of Hypothesis Fourteen, it was not possible to make a priori predictions of direction on this dependent variable. This analysis is therefore included for exploratory purposes rather than as a test of a formulated hypothesis. It is interesting to note, however, that the distribution of means for the number of homonyms treatment has reversed from that which occurred in short-term retention.

A 2x2x2 fixed-effects analysis of variance test was computed for both dependent variables. The sample size in each cell was equated at 13 prior to the analysis. The results of this test for number of words recalled and number of intrusions are also presented in Parts "A" and "B" of Table 15. The difference in total number of intrusions made by Ss presented either one or two homonym lists was the only difference which reached statistical significance ($P < 0.05$). All the other differences may be properly attributed to chance.

In view of these findings, Corollary 13c must also be <u>accepted</u> as stated in the null form.

Unlike all preceding hypotheses in this study, Hypothesis Fourteen has direct theoretical ties. Both the concept of a "stable" trace and/or Ausubel's theory of "obliterative subsumption" (Ausubel, 1963), predict that generalizations will be better retained than specifics. If this is true, one might expect retention of the principle to persist over an interval of three weeks, while retention of specific details will probably have dropped out by this point.

The principle which underlies two-homonym lists contains a derivative rule for spelling; namely, spell both exemplar terms as homonyms. The principle underlying one-homonym lists, on the other hand, contains a correlative rule for spelling; namely, spell one of the exemplar terms as a homonym. If the principle is retained, while specifics drop out, then it follows that Ss presented two-homonym lists who discover the principle will not make any spelling errors on the test for retention, while the corresponding Ss presented one-homonym lists should make several errors of this type. This conclusion follows from the differences in the nature of the spelling rules for the two types of lists as well as from the fact that remembering which term to spell as a homonym (in the case of one-homonym lists) involves recall of specifics.

Hypothesis Fourteen therefore reflects these theoretical considerations:

> Hypothesis 14 (stated in null form): Among Ss who discover the principle during acquisition, the mean number of misspelled exemplar terms on the test for long-term retention made by Ss presented one-homonym lists will be less than, or equal to, the corresponding mean for Ss presented two-homonym lists.

The mean number of spelling distortions made by Ss who discovered the principle and who reached criterion was determined for both one- and two-homonym lists. These means were 1.15 and 1.46 for one- and two-homonym lists, respectively. The obtained means were therefore distributed in the opposite direction from that predicted. Thus, the null statement of Hypothesis Fourteen must be accepted without further analysis.

In short, tests of Hypotheses Eleven through Fourteen all point toward one conclusion. Those Ss who discovered the principle during acquisition were apparently unable to utilize the principle during the test of long-term retention.

CHAPTER V

DISCUSSION AND CONCLUSIONS

I. Higher-Order Coding Schemes and Short-Term Retention

The effect of higher-order coding schemes on short-term retention was examined in tests of Hypotheses One through Four. These tests confirm the following general conclusions:

(1) Approximately 50% of the Ss in this study were able to perceive and to utilize the principle by which each triad was constructed.

(2) Those Ss who discovered the principle formed the necessary associations more rapidly than Ss who did not discover the principle.
   (a) Ss who discovered the principle on the first learning trial recalled more words correctly on the first test trial (Experiment II).
   (b) Ss who discovered the principle at some point during learning trials 1-8 recalled more words correctly over all 8 test trials, and took fewer trials to reach criterion than Ss who did not discover the principle (Experiment I).

(3) In general, Ss who discovered the principle at some point during the task made fewer intrusions in recall over test trials 1-8 than Ss who did not (Experiment I).

(4) But there was little or no difference in number of intrusions on the first test trial made by Ss who either did or did not discover the principle during the first learning trial (Experiment II).

There is a notable agreement between the percent of Ss who discovered the principle in this study and the reported proportion of Ss who discovered that they could transform letter trigrams into words in Underwood and Keppel's study (1964). In both cases, the proportion of Ss who discovered the relevant "built-in" encoding scheme was roughly 50%. Furthermore, in both tasks this discovery lead to enhanced performance. In Underwood and Keppel's study (1964), for example, when Ss were allowed to recall the letters in each trigram in any order, transforming the letters into words resulted in sizeable gains in recall. The conclusions of this study which are listed above also suggest that discovery of the relevant higher-order coding scheme led to superior performance scores across all measures of immediate retention.

However, a more detailed analysis of the results of this study suggests that this superiority held only for measures of recall and number of intrusions over all eight test trials of Experiment I, as well as recall on the single trial of Experiment II. Differences in number of intra- and extra-list intrusions made by Ss who either did or did not discover the principle failed to reach statistical significance on the single test trial of Experiment II.

A full account of these findings must therefore begin with a discussion of the nature of intra- and extra-list intrusions. Gibson's somewhat controversial discussions of generalization and differentiation (1940) seem most appropriate to this discussion. Gibson maintains that a major necessity of verbal learning is the formation of discriminations among the items to be learned. When a response is formed to a given stimulus, there is a concurrent tendency for all similar stimuli to evoke the same response (stimulus generalization). There is also an increased tendency for the given stimulus to evoke similar responses (response generalization). Thus, prior to the development of discriminations among stimulus items on the list, a response which should be given to Stimulus "a", may be given to Stimulus "b" because of the similarity between "a" and "b". Stimulus generalization would therefore seem to account for intra-list intrusions. Furthermore, response "b", instead of the correct response "a", may be given to a certain stimulus because of a similarity between responses "a" and "b". Thus, response generalization would seem to account for extra-list intrusions.[25] Although both intra- and extra-list intrusions are overt responses stemming from a lack of differentiation between appropriate stimuli and appropriate responses respectively, inappropriate

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[25]Extra-list intrusions may also stem from the perceived relations among the terms in each triad. Such relations, or encoding schemes, may suggest certain incorrect responses. An example of this is the response "animal" to a stimulus selected from the triad <u>mammal-dear-bear</u>. This response is likely to occur if the S perceives that all three terms in the triad are animals. Unfortunately, it is impossible to differentiate between this source of errors, and response generalization since "animal" is also highly similar to the term "mammal". Number of misspelled exemplar terms therefore provides the only direct index of the strength of this factor.

responses may also occur covertly. Under these conditions, the covert response may merely inhibit the correct response which also tends to occur.

Errors in spelling may also result from a lack of differentiation. Here the source of the error rests in improper discrimination between the spelling of each term as it appears on the list and the spelling which is suggested by the encoding scheme adopted by the S. If a S notes only that the exemplar terms fit some category, for example, then there will be a strong tendency to spell these terms as exemplars of that category rather than as homonyms of the correct exemplar terms. Ss who discover the one-homonym principle are also faced with the task of discriminating between the term which is spelled as an exemplar and the term which is spelled as a homonym within each triad.

This explanation is supported by the results of at least three experimental studies (Underwood, 1949; Underwood and Hughes, 1950; and, Deese, 1959a). Perhaps the strongest evidence was provided by Underwood and Hughes (1950) who found that on a test of one-week retention of nonsense syllable-adjective pairs, the more similar the extra-list errors were to the correct response, the greater the frequency with which these errors occurred. A rather crude analysis which was conducted in this study also lends support to this explanation of extra-list intrusions.[26] A simple frequency count was made

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[26]Underwood and Hughes (1950) note the complexities involved in an elaborate analysis and recommend that no one

of the number of times a given term appeared as an extra-list intrusion in this task. In general, the most frequently occurring terms bore a strong similarity to the correct response (e.g., "foot" instead of "feet"). These results are depicted in Table 21 of Appendix C.

The above discussion suggests that a critical phase of any verbal associational task is the formation of certain discriminations. Each S must not only learn to discriminate between similar stimuli which appear on the list, but he must also learn to distinguish between the correct response to a given stimulus and similar responses which also tend to be elicited by the stimulus. Prior to the establishment of these discriminations, incorrect responses are apt to appear either covertly, resulting in response competition, or covertly as intra-list and extra-list intrusions, respectively.

When viewed in terms of this discussion, Underwood's paradigm of associational learning (1962), appears to be somewhat incomplete. Underwood states,

> The first stage is the response-learning stage during which a S must acquire the response-terms so they are readily available in recall. The second stage is the associative stage during which an association is formed between the stimulus and the response term. (Underwood _et al_., 1962, p. 353).

Thus, Underwood gives no attention to discrimination learning.

By modifying Underwood's model to include a third, or discrimination stage, it is possible to account for the

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attempt to analyze extra-list intrusions without somehow structuring the task so that errors of a certain type are apt to occur. This advice was followed by Deese (1959a).

findings of this study. The modified model differs from Underwood's paradigm only by the addition of a third stage. Thus, the above quotation adequately describes the first two stages of the revised paradigm. The third stage, however, involves discrimination learning: namely, differentiation between similar stimuli as well as differentiation between correct responses and similar response terms which do not appear on the list.

This revised paradigm suggests that Ss who discover the principle in this task may enjoy advantages over those who do not during both the second and third stages of associational learning. During the associational stage, for example, discovery of the principle results in the acquisition of a single coding scheme which may be used to relate the terms in all nine triads. Ss who do not discover the principle, on the other hand, must not only devise none distinct relationships among the terms in each triad, but they must somehow retain these nine coding schemes as well. Thus, Ss who discover the principle approach each early test trial effectively armed with nine associational aids, while Ss who do not discover the principle probably approach each early test trial with less than nine associational aids. This would explain why Ss who discover the principle recall more words correctly than Ss who do not as early as the first test trial.

Ss who discover the principle also enjoy an advantage during the discrimination stage. Discovery of the principle brings with it the immediate termination of the second, or associational stage. At this point, a S who discovers the principle may devote his full attention to the unique attributes of the terms in each triad in an attempt to master the necessary discriminations. Ss who do not discover the principle, on the other hand, must give some attention to determining relations among the terms in those triads for which they have not developed verbal codes. Thus, these Ss are able to give only partial attention to the unique attributes of the terms in each triad. This would explain why Ss who discover the principle make fewer intrusions in recall over all eight test trials. The fact that discrimination learning follows the formation of associations would also explain why the two groups did not differ in number of intrusions on the first test trial.

Further support for the three stage model is derived from a study by Spiker (1960) as well as from one further analysis of the data obtained in this study. Spiker provided an experimental group of fifth graders with four sentences by which they could relate four pairs of words. This group was then encouraged to develop their own sentences in a second list consisting of four different pairs of words. The experimental group probably proceeded rapidly through the associational stage and were therefore faced primarily with discrimination learning. It is therefore not surprising that Ss in this group made only about one-third as many intra-list intrusions as Ss in the control group who did not receive this training.

An analysis of the spelling distortions made by Ss in this study also provides support for the three stage model. The above discussion suggests that errors for Ss who discover the principle should be concentrated in the early test trials, while errors for Ss who did not discover the principle should be more evenly distributed across all eight test trials. The cumulative proportion of spelling distortions was therefore determined for these two groups. Due to the concentration of spelling errors in the first few test trials, the author predicted that the curve for Ss who discovered the principle would be above the corresponding curve for Ss who did not discover the principle.

Figure 3 on the following page depicts the cumulative frequency distribution for these two groups for both one- and two-homonym lists. Inspection of this figure reveals that the curves are distributed in the predicted direction. A one-tailed Kolmogorov-Smirnov test was therefore computed to determine whether or not the two distributions were significantly different (Siegel, 1956). Using the maximum difference of 0.234 on the fourth test trial for one-homonym lists, and the maximum difference of 0.256 on the second test trial for one-homonym lists, the obtained Chi-squares were 9.072 and 19.158 for one-homonym and two-homonym lists, respectively (df = 2). Thus, differences between the two groups are

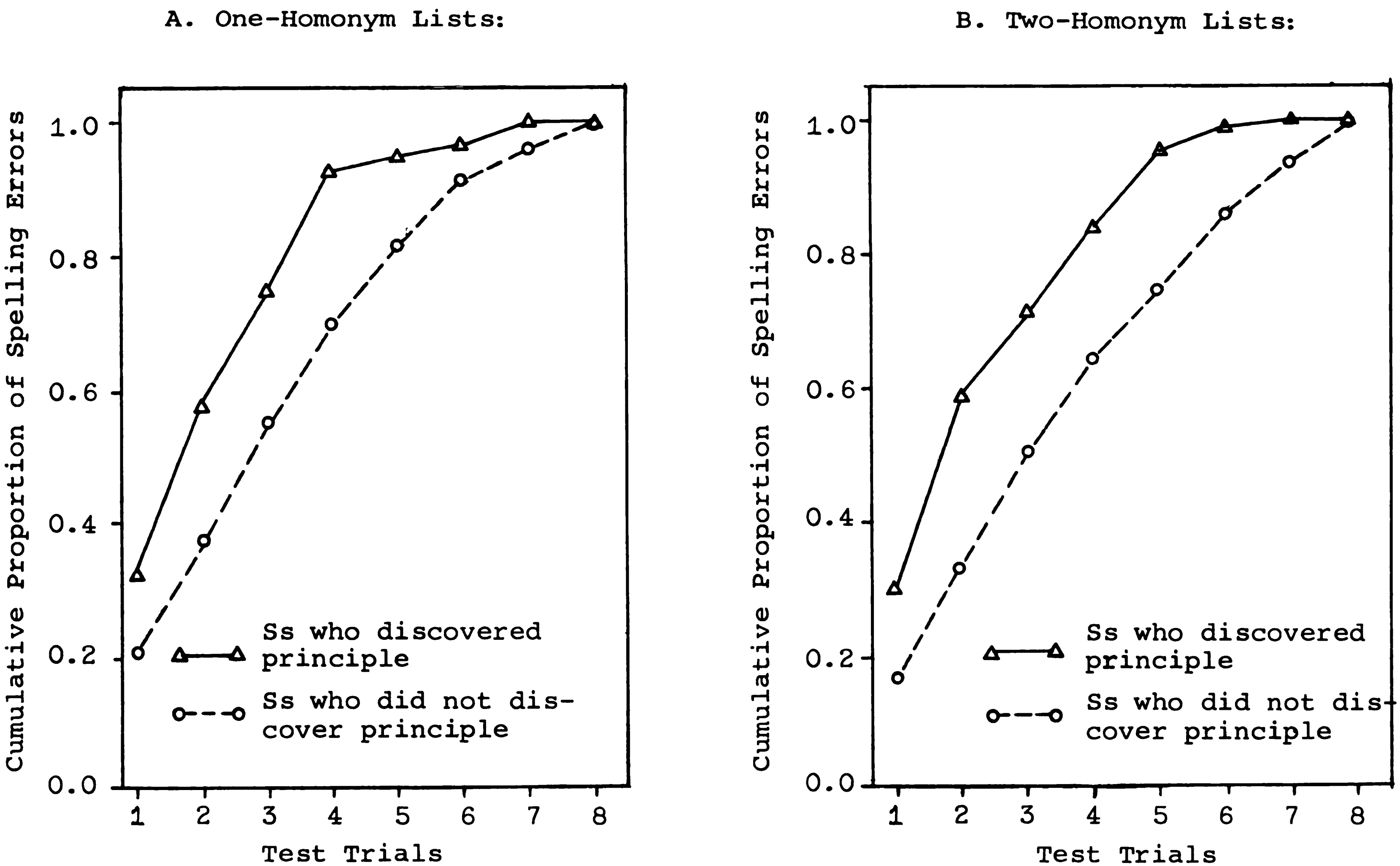

Figure 3. Cumulative proportion of spelling distortions made by Ss who either did or did not discover the principle (Experiment I).

statistically significant for one-homonym lists ($P < 0.05$), as well as for two-homonym lists ($P < 0.01$).

This finding follows logically from the three-stage model of associational learning, but could not be predicted from Underwood's two stage model. It therefore appears that the three stage model more adequately accounts for the findings of this study. However, statements regarding the generality of the paradigm await further investigation.

II. Configural Perception and the Encoding Process

The effect of configural perception on the development of higher-order coding schemes was examined in tests of Hypotheses Five and Six. These tests confirm the following general conclusions:

(1) If perceptual cues do affect the likelihood that a given S will discover the principle, then this effect is generally limited to the early test trials:
  (a) Differences in the per cent of Ss who discovered the principle on the first learning trial approached significance for one- and two-homonym lists as well as for capitalization or non-capitalization of the categorical terms ($0.05 < P < 0.10$).
  (b) But only the difference between capitalization and non-capitalization remained at this level by the completion of the task.
  (c) Order of presentation within each triad had little or no effect on discovery of the principle at any point during the learning task.

The effect of perceptual cues on short-term retention was examined in tests of Hypotheses Seven through Ten. These tests confirm the following general conclusions:

(2) The short-term retention of Ss presented one-homonym lists is clearly superior to that of Ss presented two-homonym lists. Differences between these two groups were statistically significant on every measure of short-term retention ($P < 0.01$).

(3) No conclusive statement may be made in regard to the effect of capitalizing or not capitalizing the categorical terms on short-term retention. It would appear that if this variable does have an impact on performance, then this effect is almost totally limited to one-homonym lists.
   (a) Differences between the two conditions on this variable failed to reach a statistically significant level on any measure of short-term retention.
   (b) But the interaction between number of homonyms and capitalization was significant when total number of intrusions served as the dependent variable ($P < 0.01$) and approached significante on nearly every other dependent variable. The distribution of means in each of these interactions suggests that differences between the two conditions were sizeable on one-homonym lists, but extremely small on two-homonym lists.

(4) Order of presentation within each triad has little or no effect on short-term retention. None of the differences between the two conditions on this variable even approached statistical significance.

The most consistent differences in performance occurred for one and two-homonym lists. These two lists vary according to the number of terms which must be transformed into their homonyms before the underlying principle is apparent. They might thus be said to vary in the degree of embeddedness of the underlying principle. Since the two groups did vary in performance, the obvious conclusion would be to say that this difference arose from the difference in the perceptual attributes of the two lists. Unfortunately, however, the two lists have two other systematic differences which may also have contributed to the obtained difference in performance--

frequency of occurrence of the terms, and degree of established association among the terms in each triad.

First, 18 of the 27 terms on the two lists are identical; namely, the categorical and misspelled exemplar terms. But the other nine terms are unique to each list. As noted in Chapter III, the unique terms on one-homonym lists occur somewhat more frequently in printed texts than the corresponding terms on two-homonym lists. Since frequency of occurrence is related to recall, this difference would tend to favor performance on one-homonym lists. But if this factor has a significant bearing on the obtained difference between one- and two-homonym lists, then there should be a sizeable difference in number of unique terms recalled and little or no difference in the recall of the 18 identical terms, i.e., there should be a significant interaction between number of homonyms and type of response. But when this interaction was examined over the first three test trials, the resulting F-ratio equalled 0.17 (see Table 12 in Chapter IV).

This finding suggests that the difference in recall of identical terms between Ss presented one- and two-homonym lists was approximately equal to the corresponding difference in recall of unique terms. Therefore, the obtained difference between one- and two-homonym lists cannot be solely attributed to the difference in frequency of occurrence of the terms which appeared in each.

Second, the degree of established association among the terms in each triad also seems to favor performance on one-homonym lists. The association between the categorical and exemplar terms on one-homonym lists is well established prior to the time the S enters the task (e.g., mammal-bear). But the corresponding association on two-homonym lists is extremely arbitrary (e.g., mammal-bare).

On the other hand, differences in degree of established association are minimal for the other two types of associations. The exemplar-misspelled exemplar associations are arbitrary for both types of lists (e.g., bear-dear and bare-dear) and the categorical-misspelled exemplar associations are identical in both lists (e.g., mammal-dear). Therefore, if the difference in degree of established association plays a critical role in the obtained difference in performance on one- and two-homonym lists, there should be a significant interaction between number of homonyms and type of association.

Table 16 on the following page depicts the means in this interaction. Examination of this Table reveals that differences were actually smallest for the categorical-exemplar associations. One must therefore conclude that the difference in degree of established association between the terms in one- and two-homonym lists cannot fully account for the obtained difference in performance on these two lists.

Since neither of these variables can fully account for the obtained difference in performance, it would seem

Table 16. The mean number of words correctly recalled over the first three test trials (total possible = 18) for each condition in the interaction between number of homonyms and type of association.

	Categorical-misspelled exemplar	Categorical-exemplar	Exemplar-misspelled exemplar
One-Homonym Lists (N = 113)	12.50	11.83	11.84
Two-Homonym Lists (N = 105)	10.32	10.47	9.66
Difference in Means for the two lists	2.18	1.37	2.18

reasonable to attribute this difference to the relative degree of embeddedness of the underlying principle on one- and two-homonym lists. As described earlier in this section, the fact that the principle underlying one-homonym lists is apparent following the transformation of a single term in each triad into its homonym suggests that this principle should be discovered fairly rapidly. The difference in the proportion of Ss who discovered the principle during the first learning trial which was very nearly significant offers some support for this assertion. This difference should, in turn, give rise to the obtained difference in performance on one- and two-homonym lists.

Before accepting this explanation, however, one further finding must be considered. According to the above logic, the difference in performance on one- and two-homonym lists should disappear if the per cent of Ss who discovered the principle is equated for both groups. Yet in an earlier analysis when this occurred, the mean number of words recalled by Ss presented one-homonym lists remained significantly larger than the corresponding mean for two-homonym lists ($P < 0.01$).[27] Therefore, the obtained difference in performance on one- and two-homonym lists does not stem solely from the difference in proportion of Ss who discovered the principle during the initial learning trials.

In short, none of the three variables which have thus far been considered can fully account for the decisive superiority of performance by Ss presented one-homonym lists. The most reasonable conclusion therefore appears to be that this superiority stemmed from an additive combination of all three factors. However, an equally strong possibility is that this difference stemmed from an interaction between two or more of the factors. Consider the interaction between degree of embeddedness and degree of established association.

The difference in degree of embeddedness of the principle underlying one- and two-homonym lists stems from the fact that two terms must be transformed into homonyms before the principle underlying two-homonym lists becomes apparent, while

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[27] See Table 12 in Chapter IV.

only one term must be transformed on one-homonym lists. The principle underlying one-homonym lists is therefore more obvious simply because fewer terms have to be transformed in the derivation of this coding scheme.

In addition to this difference in number of terms which must be transformed, a second factor may also contribute to the difference in degree of embeddedness of the underlying relationship; namely, degree of established association among the terms in each triad. The existence of a previously established association among two of the terms in each triad on one-homonym lists may have a decisive impact on performance because it contains a strong suggestion that the third term should be transformed into its homonym. Suppose, for example, that a S notes that wine and beverage both involve drinking, or that mammals and bears are both animals. Conscious recognition of this relationship may also suggest that a simple transformation of the third term makes it an exemplar of the category as well. If bier is changed to beer, for example, it is also a drink. Thus, one-homonym lists contain an implicit hint that a transformation of terms should be made; namely, the established association among two of the terms in each triad.

Two-homonym lists, on the other hand, lack this suggestion that any transformations should occur. Ss may therefore continue to react to each term as it is written on the list over a longer interval of time. If one reacts to whine as a form of crying, for example, then it is difficult to see how this term might be included in a common category with beverage. Since there is no hint of this categorical relationship, there is also no reason to perceive that bier should be transformed to beer. In the absence of any suggestion of a categorical relationship, it is even possible that many Ss in this group began to look for syntactical relationships such as "He whined in his beverage as the bier passed by." An early commitment to this strategy would clearly interfere with the likelihood that a S would discover the principle.

In short, there are two interacting factors which may contribute to the ease with which a given S may derive the underlying principle--number of homonyms which must be transformed and the extent to which the utility of making these transformations is suggested by previously established associations among the terms. Ss presented one-homonym lists are at an advantage over Ss presented two-homonym lists on both of these factors.

Perhaps even more important is the fact that these two factors probably also contribute to the ease with which Ss may derive any first-order coding schemes among the three terms in each triad. Ss presented two-homonym lists are handicapped by the fact that unless two terms in each triad are transformed into their homonyms, the derivation of any relationship, other than a syntactical relationship, is extremely arbitrary. And, as is evident from the above discussion, there is no implicit hint that such transformations should be made. Ss presented one-homonym lists, on the other hand, are faced with the task of incorporating only one arbitrary term into each first-order coding scheme. Furthermore, the existence of an established association between two of the terms suggests how this incorporation might be easily accomplished; namely, transforming the term into its homonym so that it also becomes an exemplar of some category.

One might therefore expect that among those Ss who do not discover the principle, Ss presented one-homonym lists will have established first order coding schemes more rapidly than the corresponding Ss presented two-homonym lists. The results of several studies, such as Martin *et al*. (1965a), suggest that this early advantage should, in turn, contribute to the obtained difference in performance between these two groups of Ss.

In short, the interaction between number of terms which must be transformed and degree of previously established associations among the terms in each triad would seem to account for the obtained difference in performance between Ss presented one- and two-homonym lists. This follows from the fact that differences along these two variables give rise to differences in the proportion of Ss who discover the principle early in the learning process as well as to differences in the speed with which first-order coding schemes are derived by those Ss who do not discover the principle.

Perhaps more important, these same two variables may also account for the significant interaction between number of homonyms and capitalization of the categorical terms. The two easily related terms in each triad on one-homonym lists suggest not only that a transformation of one term in each triad should be made, but they also suggest the nature of the first order relations which should be established; namely, categorical relationships. It is possible that the differential attention drawn to the categorical terms by capitalization may suggest the specificity of this relationship. Suppose, for example, that a S notes that <u>beverage</u> and <u>wine</u> are both drinks, and that when <u>bier</u> is changed to <u>beer</u>, it is also a drink. Capitalizing a categorical term may cause the S to take another look at this term. In the process he might note that <u>beer</u> and <u>wine</u> are both beverages. If a closer analysis of the other triads results in a similar discovery of the more specific category, then the S is well on his way to discovery of the relevant principle. In the absence of capitalization, on the other hand, the S might remain content with the derivation of first-order coding schemes such as "They are all drinks."[28] In short, capitalization of the categorical terms on one-homonym lists may have

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[28]It is clear that if a S derived an extra-list category for each triad, such as "drinks," he would have derived a higher-order coding scheme. The likelihood of this occurring is extremely small, however, due to the lack of an obvious extra-list category for such triads as "weather-son-rain."

Therefore, in all probability, those few Ss who derived a first-order relation for each triad on the list used some extra-list and some intra-list categories, thus precluding the use of the same coding scheme for each triad.

frequently led to the discovery of the principle.

Turning to two-homonym lists, the absence of an established association among two of the terms in each triad may have eliminated the effect of capitalizing the categorical terms. First, the absence of this easily recognized relationship reduces the likelihood that Ss will initially attempt to derive categorical relationships. Should a S attempt to derive syntactical relationships, for example, then differential attention to the categorical terms would have absolutely no impact on performance. Second, unless the S perceives that two of the terms in each triad should be transformed into their homonyms, the categorical terms are no more suggestive of any first-order coding schemes than either of the other two terms. Since two-homonym lists lack any implicit hints that such transformations should be made, the impact of capitalizing the categorical terms may be minimal during the initial test trials.

In short, this explanation suggests that capitalizing the categorical term should enhance the probability of discovering the principle on one-homonym lists, while registering little or no impact on the likelihood of discovering the two-homonym principle. Differential discovery of the principle, should in turn, yield the obtained differences in performance.

Although the explanation which seems to parsimoniously account for the major findings of this phase of the research is post hoc in nature, it is nevertheless highly suggestive of further research. Such research might take the form of free-associations to the terms in each triad, presented either individually or in pairs, in an attempt to determine which terms elicit the greatest number of relevant categorical responses. These critical terms might then be perceptually isolated using either differences in the size of print (similarity) or differences in the physical distance between the terms in each triad (contiguity). If the above explanation is sound, the resulting differential attention to these terms should have an impact on the derivation of first-order coding schemes as well as discovery of the principle which, in turn, will enhance performance.

The primary improvement of this study over that described in this dissertation would rest in the fact that the critical terms would be empirically determined, while in this study, it was assumed that the categorical terms were more highly suggestive of the principle than either of the other two. And, as described above, the results tend to raise a serious question regarding the validity of this assumption.

III. Higher-Order Coding Schemes and Long-Term Retention

The effect of the derivation of higher-order coding schemes on long-term retention was examined in tests of Hypotheses

Eleven through Fourteen. These tests support the following two conclusions:

(1) Those Ss who discovered the principle during acquisition did not perform at higher levels on the test of long-term retention than Ss who did not discover the principle. Differences between Ss who either did or did not discover the principle did not approach significance on any measure of long-term retention.

(2) None of the three perceptual variables had the predicted effect on long-term retention. Not only did the difference between the two conditions on each variable fail to reach a statistically significant level, but in several tests the two means were distributed in the opposite direction from that which was predicted.

These two findings may probably be combined into a single conclusion; namely, that the vast majority of Ss who discovered the principle during acquisition were not able to utilize this principle on the test for long-term retention. Two further findings also point to this conclusion. First, Ss presented two-homonyms lists made more spelling distortions than Ss presented one-homonym lists despite the fact that the principle underlying the former lists contained a derivative rule for spelling, while the corresponding spelling rule for one-homonym lists was correlative in nature. Second, an indirect measure of retention of the principle for Ss presented two-homonym lists revealed that at least 72.5% of the Ss who discovered the two-homonym principle during acquisition did not utilize this principle on the test for long-term retention. (See Table 23 in Appendix C for an explanation of this finding.)

Before accepting this explanation, however, two alternatives should be considered; namely, that the differences were not significant due to the selectiveness of the sample used in tests of long-term retention, or to the greater opportunity for overlearning among those Ss who did not discover the principle.

First, comparisons of short-term retention were based on every S in the sample, while comparisons of long-term retention were based on only those Ss who reached criterion. It is therefore possible that differences in short-term retention did not exist among Ss in this more select sample. In lieu of this possibility, the entire analysis of short-term retention was replicated for those Ss who reached criterion. The results of this series of t-tests are shown in Table 22 in Appendix C. Examination of this Table reveals that whereas differences were smaller among Ss in this select sample, they were nevertheless significant on all but two measures: number of misspelled exemplar terms and number of improper plurals. Since differences on the latter measure were not significant for the total sample, this explanation is limited to measures of the number of spelling distortions.

A second alternative is that differences in retention were minimized by differences in the extent of overlearning during acquisition. Ss who did not discover the principle took more trials to reach criterion than Ss who discovered the principle, yet both groups were near the ceiling level of performance as early as the third test trial. Thus, it is likely that the extent of overlearning was greater for Ss who did not discover the principle, and it is possible that this, in turn, minimized differences in long-term retention. But if the extent of overlearning exerts a strong influence on retention, then the correlation between number of trials to criterion and number of words correctly recalled on the test for long-term retention should at least approach a positive direction.

But when this correlation was computed, it was not only negative, but significantly different from zero ($P < 0.01$). Correlations between number of trials to criterion and number of words correctly recalled on the test for long-term retention were -0.292 and -0.590 for 94 Ss in the one-homonym group and 93 Ss in the two-homonym group, respectively. The correlation for the two groups combined was -0.471. These correlations are nearly as high as the correlations between number of words correctly recalled during acquisition, and number of words correctly recalled on the test of long-term retention. The combined correlation in this case equalled 0.538. It would therefore appear that the extent of overlearning did not have a significant impact on the obtained results.

Since neither alternative accounts for the findings, the most plausible explanation would seem to be that the vast majority of Ss did not utilize the principle on the test for long-term retention. If this is true, then according to Postman, one would expect no differences in recall between Ss who either did or did not discover the principle since, as this author states:

> Recoding can enhance retention only to the extent that the recoding symbols are recalled and accurate decoding follows. (Postman, 1963, p. 46.)

Since this finding came as a complete surprise, the design of this study does not permit the author to choose between two potential explanations of why so many Ss failed to utilize the principle on the test for long-term retention. First, it is possible that Ss simply failed to see the utility of reinstating the principle during recall. This possibility may follow from the function of encoding schemes during acquisition. Woodworth and Schlosberg, for example, maintain that the function of extraneous associations (encoding schemes) is to, "hold certain items together until a direct association has been established between them" (Woodworth and Schlosberg, 1938, p. 34). Evidence from studies by Reid (1938), O'Brien (1921), and Barnes and Underwood (1959) suggests that once these direct associations are formed, the relevant mediator or coding scheme tends to drop out. This author conjectured, however, that when the direct associations were weakened over time, the S would again interject the coding scheme between a given stimulus term and the two relevant responses. It is possible, however, that most of the Ss simply did not use this strategy during recall.

A second, and perhaps more reasonable, explanation is that Ss failed to use the principle on the test of retention; because they could not remember it. Since this possibility has some bearing on the dominant theories of retention, a cursory examination of each is in order. Although this study was not designed as a critical test of any theory of retention, the expressed predictions regarding long-term retention were consistent with two theories: Gestalt Theory and Ausubel's Theory of Obliterative Subsumption.

According to Gestalt Theory, acquisition results in the establishment of memory traces which are isomorphically equivalent to the incoming information. Forgetting results from changes which occur in these traces over time, these changes, in turn, result from two primary mechanisms--assimilation and autonomous disintegration. Regardless of what the organism does or learns, a memory trace will undergo a type of spontaneous decay or autonomous disintegration with resulting decrements in retention. Changes in a memory trace also occur as a result of complex interactions between the established traces and incoming traces from subsequent learning, i.e., assimilation. This interaction tends to favor incoming traces, since they are relatively more stable (Ausubel, 1964). The nature of both assimilation and autonomous disintegration gives rise to the fundamental premise of Gestalt Theory: namely, that structural or organizational traces are more stable than isolated traces.

Turning to this study, if one assumes that discovery and utilization of the principle results in a structural trace, while the derivation of nine independent coding schemes results in nine isolated traces, then it follows from Gestalt Theory that long-term retention should be superior for those Ss who discovered the principle. Since the major focus of

Gestalt Theory is on the establishment of stable traces during encoding, this prediction should hold regardless of whether of not the S utilizes the principle during recall. According to Katona's (1940) description of structural traces, the above assumption seems feasible. Katona states:

> The individual traces may be translated into everyday language as the knowledge of more-or-less unconnected facts, while the knowledge of laws and principles, of meaning and significance, of the setting and general forms, is the equivalent of structural traces. (Katona, 1940, p. 206.)

Therefore, unless Katona's statement has been misinterpreted by this author, it would appear that the results of this study clearly do not support the Gestalt theory of retention. In short, discovery of the principle, in and of itself, does not insure improved long-term retention as the Gestalt theory of retention would seem to imply.

The second theory, which is consistent with the predictions expressed in this study is Ausubel's theory of obliterative subsumption (Ausubel and Blake, 1958; and Ausubel, 1963). Ausubel maintains that as new information enters the cognitive field of the learner, it interacts with and is appropriately subsumed by a relevant and more inclusive conceptual cluster which he terms a subsumer. As a result, both the new information and the subsumer are somewhat modified. However, an established subsumer ordinarily undergoes considerably less modification than the subsumed element.

Forgetting, or obliterative subsumption, may be expressed in the following equation where "A'" represents the modified conceptual cluster or subsumer; "a'" represents the modified elements of incoming information; and "A'a'" represents the product of the interaction between "a'" and "A'":

$$A'a' \rightleftharpoons A' + a'$$

As suggested by this equation, there is a temporary equilibrium among the three components. Therefore, soon after acquisition, the individual is able to regenerate both the specific elements and their relevant subsumers (as represented on the right-hand side of the equation). Over time, however, the temporary equilibrium begins to shift toward the left. The interaction product represented in this portion of the equation suggests that the individual is no longer able to disassociate the incoming elements from their relevant subsumer. In other words, because it is more economical to retain a single inclusive concept than to remember a large battery of specific items, the individual is ultimately capable of recalling only the more generalized interaction product. Moreover, because the subsumer usually undergoes less modification than the subsumed elements, this product usually takes on the dominant characteristics of the subsumer. A fundamental premise of this theory is, therefore, highly similar to Gestalt Theory; namely, that hierarchical or organizational cognitive content (subsumers) is usually much more stabile than specific details of incoming information.

It is unfortunate from this author's point of view that Ausubel has relied on somewhat vague descriptions, rather than a specific definition in his development of the concept of a subsumer. Inferences made by this author suggest that this concept is roughly equivalent to Goss's (1961) notion of a "conceptual scheme" and that it represents the cognitive counterpart to Bartlett's (1932) "schemata". But even this does not help, since these terms are also described in a highly ambiguous fashion. The author is, therefore, forced to somewhat equivocally assume that the principles underlying one- and two-homonym lists represent appropriate subsumers. However, Ausubel's reference to "a recently learned abstract concept" in describing subsumers provides some justification for this assumption (Ausubel, 1963, p. 56).

With this assumption in mind, Ausubel's theory seems to imply that recall of the principle should persist over a fairly long interval of time, while recall of details such as which term to spell as a homonym should dissipate fairly rapidly. The fact that Ss who discovered the principle during acquisition failed to recall more words correctly or make fewer intrusions in recall than those who did not seems to raise some question regarding the validity of Ausubel's theory. The further finding that Ss who discovered the two-homonym principle made fewer spelling errors than Ss who discovered the one-homonym principle poses a more central challenge to advocates of Ausubel's theory.

It should be evident, however, that the design of this study did not represent a direct test of either Gestalt or Ausubel's theory. Several alternatives are therefore available to proponents of these two theories. To cite only one example, both might point to the highly artificial nature of the principle by which each triad was constructed. In doing so, Ausubel might argue that the principle does not represent an appropriate subsumer, and Gestalt psychologists might argue that the principle does not give rise to a stable trace. The importance of this cursory review is, therefore, not to provide a coup de grace of the two relevant theories, but rather to show that neither theory, no matter how extensively modified, would predict that the principle itself will be rapidly forgotten.

Since neither Gestalt nor Ausubel's theory yields a simple explanation of why Ss may have forgotten the principle, about the only remaining alternative is interference theory. Proponents of this theory maintain that retention is nothing more than a response produced by a stimulus (Osgood, 1953). Forgetting therefore results when stimuli lose their capacity to evoke previously associated responses. In simple terms, this loss results from the fact that one learns similar associations both prior to the critical task on which retention is determined (proactive interference) and subsequent to this task (retroactive interference). The negative impact of this additional learning stems from the introduction of competing responses to the critical set of stimuli. In short, when the relevant set of stimuli is re-presented, the S is forced to discriminate between the appropriate set of responses and the irrelevant set of responses which were acquired during the additional learning activity.

Due to stimulus generalization, the two sets of stimuli (critical and additional learning task) need not be identical for interference to occur. But the greater the similarity, the greater the extent of generalization between the two sets of stimuli, and therefore the greater the interference. Finally, retroactive interference may also stem partially from the fact that the critical stimulus-response associations have undergone a certain amount of unlearning or extinction during the interpolated learning activity (McGeoch and Underwood, 1943 and Barnes and Underwood, 1959). Although consideration of this unlearning factor would seem to suggest that retroactive interference will result in greater decreases in retention than proactive interference, recent evidence points to the opposite conclusion; namely, that proactive interference is a more critical factor in forgetting (Underwood, 1957).

Evidence favoring interference theory has been acquired primarily from tasks involving nonsense syllables or other stimulus materials where relations between stimuli are highly arbitrary and difficult to establish. A controversy has therefore arisen regarding the generalization of this theory to connected discourse or "meaningful learning." Some evidence, for example, suggests that the extent of retroactive inhibition is minimal for this type of material (Hall, 1955; Ausubel, Robbins and Blake, 1957; and Ausubel and Blake, 1958). But other authors have provided evidence suggesting that retroactive inhibition does occur for connected discourse (McGeoch and McKinney, 1934, and Slamecka, 1960a). Postman (1963) seems to advocate a compromise between these two extremes; he maintains that the basic assumptions of interference theory remain tenable for most forms of learning. But he also suggests that these assumptions must be supplemented by certain "principles of conservation" such as recoding (encoding) which, under some conditions, have been shown to systematically reduce the amount of forgetting.

By carrying Postman's analysis one step further, it may be possible to account for all types of forgetting within an interference framework without citing exceptions to the basic assumptions. This parsimony may be accomplished by shifting from the current concern with similarities in the systematic properties of the stimulus and response terms to a concern with similarities between the encoding schemes adopted during the critical and additional learning tasks. In short, forgetting may result from an interference between highly similar coding schemes which are adopted during these two tasks. There is some evidence to support this assertion. Martin's (1965a) research, for example, suggests that strategies (encoding schemes) adopted during paired-associate tasks tend to involve systematic properties of the stimulus and response terms, e.g., the same combination of letters in the two terms. As a result, one might mistakenly assume that interference results from similarities in these properties themselves when it actually results from the fact that similar properties give rise to highly similar coding schemes. Turning to tasks in which relations between the stimulus and response terms are not arbitrary, but rather involve meaningful and/or well-established relations, the evidence is less equivocal. Slameka (1959 and 1960b), for example, has shown that the extent of retroactive inhibition is a direct function of the similarity between the themes or topics of critical and interpolated passages of connected discourse. Since Bartlett (1932) has shown that retention of connected or meaningful material is based on translations of this material into basic themes, it follows that the critical element in these studies is interference among the adopted coding schemes. Finally, two studies have shown that both proactive and retroactive interference occurs when two sets of materials are based on closely related principles (Postman, 1954; and Entwisle and Huggins, 1964).[29]

Turning to this study, a high degree of similarity does exist between the principle (coding scheme adopted by those Ss who discovered the principle) and the well-established

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[29]The results of Postman's (1954) study were not statistically significant.

method of classifying those terms which appeared on the list. The following statement by Postman therefore seems relevant.

> To the extent that the prescribed associations are consistent with pre-existing language habits, positive transfer, and facilitation at recall are to be expected. When there is competition between the required response sequences and prior language habits, there should be negative transfer and interference at recall. (Postman, 1963, p. 40.)

It is therefore possible that the similarity between the established means of classifying the terms on each list and the general nature of the principle gave rise to a high degree of proactive interference between these two coding schemes. This interference would in turn account for the fact that many Ss forgot the principle.

In summary, there are two potential explanations for the conclusion that the vast majority of Ss who discovered the principle did not utilize this principle on the test for long-term retention. First, it is possible that Ss simply did not adopt this strategy during recall, despite the fact that they could have recalled the principle. Studies showing that mediators tend to drop out during acquisition provides some evidence for this position. Second, Ss may not have utilized the principle during recall, because they could not recall the principle. As shown above, a simple modification of interference theory could account for this alternative.

Unfortunately, the design of this study does not provide conclusive evidence for either alternative. However, further research could readily provide this evidence. Suppose, for example, that immediately prior to the recall trial Ss are instructed to use whatever relations they derived during acquisition as aids in recall. If differences fail to occur under these conditions, one may conclude that many Ss have forgotten the principle. But if differences do occur, then the relevant conclusion is that Ss did not realize the utility of reinstating the principle during the test for retention.

IV. Implications for Education

Although this investigation would be classified as "pure research" according to Hilgard's scale (1964), the major findings may nevertheless raise certain questions regarding educational practice.

The first finding which should be considered is that those Ss who derived higher-order coding schemes in this task performed at a higher level during acquisition than those who did not. This result seems to suggest that the coding activities of the learner will have a significant impact on the acquisition phase of some learning tasks. If this generalizations is valid, then two implications follow. First, a teacher may better understand the source of differences among learners if he determines what coding schemes have been adopted by each. Second, it may be possible to increase learning efficiency in certain tasks through instruction aimed at improving the coding skills of students.

The first of these implications may pose a problem for teachers; namely, how might they efficiently determine what coding schemes have been adopted by a given student? Fortunately, this investigation suggests a solution. Due to frequent errors in completing the L.P.F.Q., two independent methods were used to identify those Ss who had derived a higher-order coding scheme: verbal reports and performance tasks involving transfer of the principle. As described in Chapter III, there were no differences in performance among Ss identified by either of these methods. Thus, verbal reports seemed to be as effective as transfer of training tasks in identifying Ss who had derived a higher-order coding scheme.

This finding clearly implies that teachers need not be reluctant to ask students what process they have used to master a given task.[30] This method of identifying the coding schemes adopted by a given student is not only more direct than interences of process based on transfer of training, but it also has a wider range of application. Thus, it would seem to be to the teacher's advantage to ask each student how he has gone about mastering a given task. This teaching strategy may, in turn, yield better understanding of the source of differences in acquisition among students.

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[30]It should perhaps be noted that this suggestion directly counters the position which a majority of psychologists take; namely, that any form of introspection should be avoided in attempts to determine the process by which a S has mastered a given task. But, no matter how reasonable any argument posed by the anti-introspection position may seem, it fails to counter the consistent finding that verbal reports account for a significant proportion of the variance in performance among Ss (see Chapter II). The results of this investigation further suggest that in certain situations, verbal reports are as effective in identifying process variables as methods which avoid the use of verbal reports, i.e., inferences based on transfer of training.

The second implication suggests that learning efficiency may be improved in certain tasks through the use of instruction aimed at improving the coding skills of the learner. It should be noted, however, that the results of this investigation provide logical, rather than empirical support for this assertion. Unfortunately, there is no clear empirical evidence, either pro or con, which is relevant to this implication. A definite need for further research therefore exists.

A corollary implication is that both teachers and students should receive some instruction regarding the limitations of human memory. Such training may suggest to teachers that it is unreasonable to expect students to "know everything." This instruction may also show students that there is a need to efficiently condense whatever they are attempting to remember. The provision of this training might therefore prove to be a valuable antecedent to training in coding skills.

The second major finding of this investigation which should be considered is that perceptual cues had little or no effect on the likelihood that a given S would discover the principle. Even the presentation of one- and two-homonym lists where one "built-in" relationship seemed far more obvious than the other had virtually no effect on the per cent of Ss who ultimately discovered the principle. In a general sense, this finding seems to suggest that it may be virtually impossible to exert control on the cognitive activities of the learner through variations in the manner of presenting a given set of stimulus materials. Specifically, it implies that attempts to perceptually isolate those elements which are deemed most critical to a given cognitive process will have little or no effect on the likelihood that a given S will adopt that process during the learning activity.

Suppose, for example, that a teacher capitalizes those letter combinations within each word which are known to generate the most errors in spelling. The results of this investigation suggest that the perceptual isolation of these "critical elements" will have little impact on the process by which the student will learn to spell. It is therefore not surprising that this teaching strategy has been found to be no more effective than the presentation of spelling lists in which all letters are written in small print (TenBrink, 1966).

As a second example, suppose that a teacher capitalizes all prefixes and suffixes in an attempt to increase the likelihood that a student will use "intra-word context cues" in pronouncing unfamiliar words.[31] The above implication suggests that this perceptual isolation will have little effect on the likelihood that a given S will use these cues as an aid in pronunciation. Capitalizing prefixes and suffices will therefore have little effect on a student's ability to pronounce unfamiliar words.

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[31]Carroll (1964) discusses a number of cues which a reader might adopt in his attempts to pronounce an unfamiliar word.

These two examples are consistent with the assertion that attempts to perceptually isolate critical elements will probably not have a significant impact on the coding activities of the learner. However, further research must be undertaken to determine the validity and/or legitimate range of this generalization. It is possible, for example, that the effect of perceptually isolating certain elements may depend upon the particular coding scheme which one is attempting to facilitate, or upon the particular elements which have been isolated.

The final result which should be considered is that the long-term retention of Ss who derived higher-order coding schemes during acquisition did not exceed the corresponding performance of Ss who initially derived a set of first-order coding schemes. This finding seems to imply that during tests of long-term retention, a majority of Ss will not be able to utilize those encoding schemes which they have derived during acquisition.

Admittedly, however, this may be a gross overgeneralization. The higher-order coding scheme (principle) which some Ss derived during this investigation was not only highly artificial, but it was also appropriate to only one laboratory task. Thus, Ss may have seen little advantage in attempting to remember it.

Despite this limitation, this result poses at least two questions which should be answered by empirical research. First, is the facilitating effect of coding schemes restricted to acquisition or short-term retention in all learning tasks?

If not, is there any relation between the specificity of a given coding scheme and the likelihood that a S will be able to remember that scheme over long intervals of time? Second, are higher forms of learning such as principles subject to the same basic laws of interference as lower forms such as isolated facts?

Answers to both of these questions have clear implications for education.

V. Conclusions

The results of this investigation provide partial support for at least six major conclusions. The author is convinced that future research will confirm each of these generalizations.

(1) When presented with an associational task, some, but not all, Ss will look for general relationships which hold for more than one pair (or triad) of stimulus and response terms, i.e., will attempt to derive higher-order coding schemes. Therefore, investigators who focus their attention on relationships or strategies which are derived for each pair of terms and who ignore the potential impact of interrelationships among these strategies, may be overlooking an important source of inter-individual variance.

(2) In those associational tasks where it is possible to derive a single higher-order coding scheme, Ss who discover

this scheme will not only form the required associations more rapidly than those who do not, but they will also make fewer intrusions in short-term recall.

(3) Associational learning should be viewed as a three-stage process--response learning, associational learning, and discrimination learning. The addition of discrimination learning to Underwood's (1962) two-stage model stems from an analysis of the intrusions in recall which occurred in this task. This analysis suggests that Ss must learn to differentiate between relevant and irrelevant stimuli, as well as between relevant and irrelevant responses. Failure to form these discriminations will result in either covert-competing responses or overt responses in the form of intra-list and extra-list intrusions.

(4) Although the results of this study do not provide conclusive evidence regarding the role of perception in the formation of higher-order coding schemes, the methodological technique which was employed does show promise. Future investigations which utilize lists with "built-in" relationships between the stimulus and response terms, together with the perceptual isolation of those terms (or pairs of terms) which are most suggestive of this relationship should provide more affirmative evidence regarding this rather complex topic.

(5) Even in those associational tasks where it is possible to derive a single higher-order coding scheme, the discovery and utilization of this scheme during acquisition does not insure improved long-term retention. Rather, this superiority is contingent upon the recall and utilization of the relevant coding scheme during the test for long-term retention.

(6) Retention of the relevant coding scheme may, in turn, be dependent upon whether or not an individual has derived similar coding schemes in learning activities which occur either prior to or subsequent to the relevant task. Interference among similar coding schemes may not only account for the forgetting of a given coding scheme, but it may also account for forgetting generally. Although this conclusion must be regarded as tentative pending further research, the author is convinced that similarities among coding schemes represent a more critical source of interference than similarities among the formal properties of the stimulus and response terms in the relevant and irrelevant learning activities.

BIBLIOGRAPHY

Articles and Periodicals

Aborn, Murray and Rubenstein, Herbert. "Information Theory and Immediate Recall." Journal of Experimental Psychology 44: 260-266; October, 1952.

Anderson, G. Lester. "Quantitative Thinking as Developed Under Connectionist and Field Theories of Learning." Learning Theory in School Situations, E. J. Swenson, (ed.) Minneapolis: University of Minnesota Press, 1949.

Asche, S. E. "Forming Impressions of Personality." Journal of Abnormal and Social Psychology 41: 258-290; 1946.

Astin, Helen S. and Ross, Sherman. "Learning of Numbers in Differentially Shaped and Positioned Matrices." American Journal of Psychology 71: 764-765; December, 1958.

Ausubel, D. P., Robbins, L. and Blake, E., Jr. "Retroactive Inhibition and Facilitation in the Learning of School Materials." Journal of Educational Psychology 48: 334-343; October, 1951.

Ausubel, David P. and Blake, Elias, Jr. "Proactive Inhibition in the Forgetting of Meaningful School Material." Journal of Educational Research 52: 145-149; December, 1958.

Ausubel, David P. "The Use of Advance Organizers in Learning and Retention of Meaningful Verbal Material." Journal of Educational Psychology 51: 267-272; August 1960.

Baddeley, A. D. "Stimulus-Response Compatibility in the Paired-Associate Learning of Nonsense Syllables." Nature 191: 1327-1328; September, 1961.

Barclay, Allan. "Objective Mediators in Paired-Associate Learning." American Journal of Psychology 74: 373-383; September, 1961.

Barnes, J. M. and Underwood, B. J. "Fate of First-List Associations in Transfer Theory." Journal of Experimental Psychology 58: 97-105; August, 1959.

Battig, W. F. "Evidence for Coding Processes in 'Rote' Paired-Associate Learning." Journal of Verbal Learning and Verbal Behavior 5: 117-181; April, 1966.

Belbin, E. "The Influence of Interpolated Recall Upon Recognition." Quarterly Journal of Experimental Psychology 2: 163-169; Part 4, 1950.

Bolles, R. C. "The Effect of Altering the Middle of the List during Serial Learning." American Journal of Psychology 72: 577-580; December, 1959.

Bousfield, W. A. and Cohen, B. H. "The Effects of Reinforcement on the Occurrence of Clustering in the Recall of Randomly Arranged Associates." Journal of Psychology 36: 67-81; July, 1953.

Bousfield, W. A. "The Occurrence of Clustering in the Recall of Randomly Arranged Associates." Journal of General Psychology 49: 229-240; October, 1953.

Bruner, J. S. "Going Beyond the Information Given." Contemporary Approaches to Cognition. Cambridge, Massachusetts: Harvard University Press, 1957.

Bruner, J. S. "Learning and Thinking." Harvard Educational Review 29: 18 -192; Summer, 1959.

Bruner, J. S. "The Act of Discovery." Harvard Educational Review 31: 21-32; Winter, 1961.

Bruner, J. S. "Some Theorems on Instruction Illustrated with Reference to Mathematics." Theories of Learning and Instruction. N.S.S.E. Yearbook: Vol. 63. University of Chicago Press, 1964.

Bryan, W. L. and Harter, H. "Studies in the Physiology and Psychology of the Telegraphic Language." Psychological Review 4: 27-53; January, 1897.

Bugelski, B. R. and Scharlock, D. P. "An Experimental Demonstration of Unconscious Mediated Association." Journal of Experimental Psychology 44: 334-338; October, 1952.

Carmichal, L.; Hogan, H. P.; and Walter, A. A. "An Experimental Study of the Effect of Language on the Reproduction of Visual Perceived Form." Journal of Experimental Psychology 15: 73-86; February, 1932.

Carroll, John B. "The Analysis of Reading Instruction: Perspectives from Psychology and Linguistics." Theories of Learning and Instruction. N.S.S.E. Yearbook: Vol. 63, 1964.

Clark, L. L.; Lansford, T. G.; and Dallenbach, K. M. "Repetition and Associative Learning." American Journal of Psychology 73: 22-40; March, 1960.

Cofer, C. N. "A Study of Clustering in Free Recall Based on Synonyms." Journal of General Psychology 60: 3-10; January, 1959.

Cofer, C. N. "An Experimental Analysis of the Role of Context in Verbal Behavior." Transactions of the New York Academy of Science 22: 341-347; Series II, 1960.

Cofer, C. N. "Verbal Behavior in Relation to Reasoning and Values." Groups, Leadership, and Men, H. Guetzkow, (ed.) New York: Russell and Russell, 1963.

Cofer, Charles N. "Some Evidence for Coding Processes Derived from Clustering in Free Recall." Journal of Verbal Learning and Verbal Behavior 52: 188-192; April, 1966.

Cohen, Burton H. "An Investigation of Recoding in Free Recall." Journal of Experimental Psychology 65: 368-376; April, 1963.

Cohen, Burton H. "Some-or-None Characteristics of Coding Behavior." Journal of Verbal Learning and Verbal Behavior 5: 182-187; April, 1966.

Coleman, E. B. "Approximations to English: Some Comments on the Method." American Journal of Psychology 76: 239-248; June, 1963.

Corman, B. R. "The Effect of Varying Amounts and Kinds of Information as Guidance in Problem Solving." Psychological Monographs 71, No. 431: 1957.

Craig, R. C. "Directed vs. Independent Discovery of Established Relations." Journal of Educational Psychology 47: 223-234; April, 1956.

Dallett, Kent M. "Category Information in Free Recall." Journal of Experimental Psychology 68: 1-12; July, 1964.

Davidson, Robert E. "Mediation and Ability in Paired-Associate Learning." Journal of Educational Psychology 55: 352-356; December, 1964.

Deese, J. and Hardman, G. W., Jr. "An Analysis of Errors in Retroactive Inhibition of Rote Verbal Learning." American Journal of Psychology 67: 299-307; June, 1954.

Deese, J. and Kaufman, R. A. "Serial Effects in the Recall of Unorganized and Sequentially Organized Verbal Material." Journal of Experimental Psychology 54: 180-187; September, 1957.

Deese, J. "On the Prediction of Occurrence of Particular Verbal Intrusions in Immediate Recall." Journal of Experimental Psychology 58: 17-22; July, 1959(a).

Deese, J. "Influence of Inter-item Associative Strength upon Immediate Free Recall." Psychological Reports 5: 305-312; 1959(b).

Duncker, K. "On Problem-Solving." (Trans., L. S. Lees) Psychological Monographs 58, No. 270: 1945.

Eagle, Morris and Leiter, Eli. "Recall and Recognition in Intentional and Incidental Learning." Journal of Experimental Psychology 68: 58-63; July, 1964.

Earhard, Marcia. "The Facilitation of Memorization by Alphabetic Instructions." Canadian Journal of Psychology 21: 15-24; February, 1967.

Entwisle, Doris R. and Huggins, W. H. "Interference in Meaningful Learning." Journal of Educational Psychology 55: 75-78; April, 1964.

Epstein, W.; Rock, I.; and Zuckerman, C. B. "Meaning and Familiarity in Associative Learning." Psychological Monographs 74, No. 491: 1960.

Epstein, W. "The Influence of Syntactical Structure on Learning." American Journal of Psychology 74: 80-85; March, 1961.

Ewert, P. H. and Lambert, J. F. "Part II: The Effect of Verbal Instructions upon the Formation of a Concept." Journal of General Psychology 6: 400-413: 1932.

Farber, I. E. "The Things People Say to Themselves." American Psychologist 18: 185-197; April, 1963.

Feldman, S. M. and Underwood, B. J. "Stimulus Recall Following Paired-Associate Learning." Journal of Experimental Psychology 53: 11-15; January, 1957.

Foley, J. P., Jr., and Cofer, C. N. "Mediated Generalization and the Interpretation of Verbal Behavior: Experimental Study of Certain Homophone and Synonym Gradiants." Journal of Experimental Psychology 32: 169-175; February, 1943.

French, R. S. "The Effect of Instructions on the Length-Difficulty Relationship for a Task Involving Sequential Dependency." Journal of Experimental Psychology 48: 89-97; August, 1954.

Gagné, R. M. and Brown, L. T. "Some Factors in the Programming of Conceptual Learning." Journal of Experimental Psychology 62: 313-321; October, 1961.

Gagné, R. M. and Smith, Ernest C., Jr. "A Study of the Effects of Verbalization on Problem-Solving." Journal of Experimental Psychology 63: 12-18; January, 1962.

Gagné, R. M. "Problem-Solving." Categories of Human Learning, Arthur W. Melton (ed.) New York: Academic Press, 1964.

Geiser, S. and Greenhouse, S. W. "An Extension of Box's Results on the Use of the F-Distribution in Multivariate Analysis." Annals of Mathematical Statistics 29: 885-891; 1958.

Gibson, E. J. "A Systematic Application of the Concepts of Generalization and Differentiation to Verbal Learning." Psychological Review 47: 196-229; May, 1940.

Goss, Albert E. "Acquisition and Use of Conceptual Schemes." Verbal Learning and Verbal Behavior, C. N. Cofer and B. S. Musgrave (eds.) New York: McGraw-Hill, 1961.

Goulet, L. R. "Retroaction and the 'Fate' of the Mediator in Three Stage Mediation Paradigms." Journal of Verbal Learning and Verbal Behavior 5: 172-176; April, 1966.

Hall, J. F. "Retroactive Inhibition in Meaningful Material." Journal of Educational Psychology 46: 47-52; January, 1955.

Hall, J. F. and Ugelow, Alvin. "Proactive, Retroactive, and Coactive Inhibition with Meaningful Material." Psychological Reports 5: 313-317; 1959.

Haslerud, G. M. and Meyers, S. "The Transfer Value of Given and Individually Derived Principles." Journal of Educational Psychology 49: 293-298; December, 1958.

Hendrickson, G. and Schroeder, W. N. "Transfer of Training in Learning to Hit a Submerged Target." Journal of Educational Psychology 32: 205-213; March, 1941.

Hendrix, G. "A New Clue to Transfer of Training." Elementary School Journal 48: 197-208; December, 1947.

Hilgard, E. R.; Irvine, R. D.; and Whipple, R. P. "Rote Memorization, Understanding, and Transfer: An Extension of Katona's Card Trick Experts." Journal of Experimental Psychology 46: 288-292; October, 1953.

Hilgard, E. R.; Edgren, R.; and Irvine, R. D. "Errors in Transfer Following Learning with Understanding." Journal of Experimental Psychology 47: 457-464; June, 1954.

Hilgard, E. R. "A Perspective on the Relationship Between Learning Theory and Educational Practice." Theories of Learning and Instruction, N.S.S.E. Yearbook: Vol. 63, Part I; 402-415. Chicago: University of Chicago Press, 1964.

Horton, D. L. and Kjeldergaard, P. M. "An Experimental Analysis of Associative Factors in Mediated Generalization." Psychological Monographs 75: No. 515; 1961.

Howes, D. and Osgood, C. E. "On the Combination of Associative Probabilities in Linguistic Contexts." American Journal of Psychology 67: 241-258; June, 1954.

Jenkins, J. J.; Mink, W. D.; and Russell, W. A. "Associative Clustering as a Function of Verbal Association Strength." Psychological Reports 4: 127-136; 1958.

Jenkins, J. J. "Stimulus 'Fractionation' in Paired-Associate Learning." Psychological Reports 13: 409-410; October, 1963.

Jensen, Arthur R. and Rohwer, William D., Jr. "Verbal Mediation in Paired-Associate and Serial Learning." Journal of Verbal Learning and Verbal Behavior 1: 346-352; February, 1963(a).

Jensen, A. R. and Rohwer, W. D. "The Effect of Verbal Mediation on the Learning and Retention of Paired-Associates by Retarded Adults." American Journal of Mental Deficiency 68: 80-84; July, 1963(b).

Judd, C. H. "The Relation of Special Training to General Intelligence." Educational Review 36: 28-42; June, 1908.

Kendler, T. S. and Kendler, H. H. "Effect of Verbalization on Reversal Shifts in Children." Science 134: 1619-1620; November, 1961.

Kendler, Howard H. "Coding: Associationistic or Organizational?" Journal of Verbal Learning and Verbal Behavior 5: 198-200, April, 1966.

Kersh, B. Y. "The Adequacy of 'Meaning' as an Explanation for the Superiority of Learning by Independent Discovery." Journal of Educational Psychology 4: 282-292; October, 1958.

Kersh, B. Y. "The Motivating Effect of Learning by Directed Discovery." Journal of Educational Psychology 53: 65-71; April, 1962.

Kimble, G. A. and Dufort, R. H. "Meaningfulness and Isolation as Factors in Verbal Learning." Journal of Experimental Psychology 50: 361-368; December, 1955.

Kittell, J. E. "An Experimental Study of the Effect of External Direction During Learning on Transfer and Retention of Principles." Journal of Educational Psychology 48: 391-405; November, 1957.

Lindley, R. H. "Effects of Controlled Coding Cues in Short-Term Memory." Journal of Experimental Psychology 66: 580-587: December, 1963.

McGeogh, J. A. and McDonald, W. T. "Meaningful Relation and Retroactive Inhibition." American Journal of Psychology 43: 579-588; October, 1931.

McGeogh, J. A. and McKinney, F. "The Susceptibility of Prose to Retroactive Inhibition." American Journal of Psychology 46: 429-436; July, 1934.

McGeogh, J. A. and Underwood, B. S. "Tests of the Two-Factor Theory of Retroactive Inhibition." Journal of Experimental Psychology 32: 1-17; January, 1943.

Mandler, G. and Earhard, B. "Pseudo-Mediation: Is Chaining an Artifact?" Psychonomic Science 1: 247-248; September, 1964.

Marks, M. R. "Problem-Solving as a Function of the Situation." Journal of Experimental Psychology 41: 74-80; January, 1951.

Marks, M. R. and Jack, C. "Verbal Context and Memory Span for Meaningful Material." American Journal of Psychology 65: 298-300; April, 1952.

Martin, Clessen J.; Boersma, Frederick J.; and Cox, David, L. "Associative Strategies in Paired-Associate Learning." Paper read at the Midwestern Psychological Association Convention: Chicago, Illinois; 1965(a).

Martin, Clessen J.; Cox, David, L.; and Boersma, Frederick J. "The Role of Associative Strategies in the Acquisition of P-A Material; An Alternate Approach to Meaningfulness." Psychonomic Science 3(10): 463-464; 1965(b).

Martin, C. J.; Cox, D. L.; and Bulgarella, R. "Verbalization of Associative Strategies at Three Developmental Levels." Paper read at the American Psychological Association Convention: New York, New York, 1966.

Miller, George A. and Selfridge, Jennifer A. "Verbal Context and the Recall of Meaningful Material." American Journal of Psychology 63: 176-185; April, 1950.

Miller, G. A. "Human Memory and the Storage of Information." I.R.E. Transcriptions of Information Theory 2: 129-137; 1956(a).

Miller, G. A. "The Magican Number 7, Plus or Minus 2: Some Limits on Our Capacity for Processing Information." Psychological Review 63: 81-97; March, 1956(b).

Miller, G. A. "Information and Memory." Scientific American 195: 42-46; August, 1956(c).

Miller, George. "Free Recall of Redundant Strings of Letters." Journal of Experimental Psychology 56: 485-491; December, 1958.

Murdock, B. B., Jr. "The Effects of Failure and Retroactive Inhibition on Mediated Generalization." Journal of Experimental Psychology 44: 156-164; September, 1952.

Newman, Edwin B. "Forgetting of Meaningful Material During Sleep and Waking." American Journal of Psychology 52: 65-71; January, 1939.

O'Brien, Francis J. "A Qualitative Investigation of the Effect of Mode of Presentation Upon the Process of Learning." American Journal of Psychology 32: 249-283; April, 1921.

Olander, H. T. Transfer of Learning in Simple Addition and Subtraction." Elementary School Journal 31: 358-369, 427-437; January and February, 1931.

Osgood, C. E. "Meaningful Similarity and Interference in Learning." Journal of Experimental Psychology 36: 277-301; August, 1946.

Paul, Irving H. "Studies in Remembering: The Reproduction of Connected and Extended Verbal Material." Psychological Issues 1: No. 2; 1959.

Peters, H. N. "Mediate Association." Journal of Experimental Psychology 18: 20-48; February, 1935.

Pillsbury, W. B. and Raush, H. L. "An Extension of the Kohler-Restorff Inhibition Phenomenon." American Journal of Psychology 56: 293-298; April, 1943.

Pollack, I. "Assimilation of Sequentially Encoded Information." American Journal of Psychology 66: 421-435; July, 1953.

Postman, L. "Learned Principles of Organization in Memory." Psychological Monographs 68: no. 3; 1954.

Postman, L.; Adams, P. A.; and Bohm, A. M. "Studies in Incidental Learning: V, Recall for Order and Associative Clustering." Journal of Experimental Psychology 51: 334-342; May, 1956.

Postman, L. and Adams, P. A. "Studies in Incidental Learning: VII, The Effects of Contextual Determination." Journal of Experimental Psychology 59: 153-164; March, 1960.

Postman, L. "The Effects of Language Habits on the Acquisition and Retention of Verbal Associations." Journal of Experimental Psychology 64: 7-19; July, 1962.

Postman, Leo. "Does Interference Theory Predict Too Much Forgetting." Journal of Verbal Learning and Verbal Behavior 2: 40-48; July, 1963.

Postman, L. and Phillips, L. W. "The Effects of Variable Contexts on the Acquisition and Retention of Paired-Associates." American Journal of Psychology 77: 64-74; March, 1964.

Pyles, Marjorie. "Verbalization as a Factor in Learning." Child Development 3: 108-113; June, 1932.

Ray, W. E. "Pupil Discovery vs. Direct Instruction." Journal of Experimental Education 29: 271-280; March, 1961.

Reed, H. B. "Associative Aids: I. Their Relation to Learning, Retention, and Other Associations." Psychological Review 25: 128-155; March, 1918.

Reid, L. S.; Lloyd, K. E.; Brackett, N.R.; and Hawkins, W. F. "Short-term Retention as a Function of Average Storage Load and Average Load Reduction." Journal of Experimental Psychology 62: 518-522; November, 1961.

Reid, L. S.; Brackett, R.; and Johnson, R. B. "The Influence of Relationships Among Items to be Recalled Upon Short-term Retention." Journal of Verbal Learning and Verbal Behavior 2: 86-92; July, 1963.

Richardson, Jack. "The Learning of Concept Names Mediated by Concept Examples." Journal of Verbal Learning and Verbal Behavior 1: 281-288; January, 1963.

Richardson, Jack. "The Effect of B-C Presentation and Anticipation Interval on Mediated Transfer." Journal of Verbal Learning and Verbal Behavior 5: 119-125; April, 1966.

Richardson, Patricia and Voss, J. E. "Replication Report: Verbal Context and the Recall of Meaningful Material." Journal of Experimental Psychology 60: 417-418; December, 1960.

Rock, J. "The Role of Repetition in Associative Learning." American Journal of Psychology 70: 186-193; June, 1957.

Rothkopf, E. Z. and Coke, E. U. "The Prediction of Free Recall from Word Association Measures." Journal of Experimental Psychology 62: 433-438; November, 1961.

Rubenstein, H. and Aborn, M. "Immediate Recall as a Function of Degree of Organization and Length of Study Period." Journal of Experimental Psychology: 146-152; August, 1954.

Russell, W. A. and Storms, L. H. "Implicit Verbal Chaining in Paired-Associate Learning." Journal of Experimental Psychology 49: 287-293; April, 1955.

Sakoda, J. M. "Individual Differences in Correlation Between Clustering and Recall of Meaningful Words." Journal of General Psychology 54: 183-190; April, 1956.

Saul, E. V. and Osgood, C. E. "Perceptual Organization of Materials as a Factor Influencing Ease of Learning and Degree of Retention." Journal of Experimental Psychology 40: 372-379; June, 1950.

Schaub, G. Rolf and Lindley, Richard H. "Effects of Subject-Generated Recoding Cues on Short-term Memory." Journal of Experimental Psychology 68: 171-175; August, 1964.

Schulz, R. W. and Lovelace, E. A. "Mediation in Verbal Paired-Associate Learning: The Role of Temporal Factors." Psychonomic Science 1: 95-96; May, 1964.

Shanmugan, A. V. and Miron, M. S. "Semantic Effects in Mediated Transfer." Journal of Verbal Learning and Verbal Behavior 5: 361-368; August, 1966.

Shepard, R. N.; Hovland, C. I.; and Jenkins, N. M. "Learning and Memorization of Classifications." Psychological Monographs 75: No. 517; 1961.

Shepard, Roger N. "Learning and Recall as Organization and Search." Journal of Verbal Learning and Verbal Behavior 5: 201-204; April, 1966.

Shepard, W. O. and Shaeffer, Maurice. "The Effect of Concept Knowledge on Discrimination Learning." Child Development 27: 173-178; June, 1956.

Siegel, Irving. "Structure Effects Within a Memory Series." Journal of Experimental Psychology 33: 311-316; October, 1943.

Slamecka, N. J. "Studies of Retention of Connected Discourse." American Journal of Psychology 72: 409-416; September, 1959.

Slamecka, N. J. "Retroactive Inhibition of Connected Discourse as a Function of Practice Level." Journal of Experimental Psychology 59: 104-108; February, 1960(a).

Slamecka, N. J. "Retroactive Inhibition of Connected Discourse as a Function of Similarity of Topic." Journal of Experimental Psychology 60: 245-249; October, 1960(b).

Spielberger, Charles D. and Levin, Saul M. "What is Learned in Verbal Conditioning?" Journal of Verbal Learning and Verbal Behavior 1: 125-132; September, 1962.

Spiker, Charles C. "Associative Transfer in Verbal Paired-Associate Learning." Child Development 31: 73-87; March, 1960.

Stacey, Chalmers L. "The Law of Effect in the Retained Situation with Meaningful Material." Learning Theory in School Situations, E. J. Swenson, G. L. Anderson, and C. L. Stacey. Minneapolis: University of Minnesota Press, 1949.

Suppes, Patrick. "Towards a Behavioral Psychology of Mathematics Thinking." Unpublished Manuscript, Stanford University, 1963. Reported in Bruner, J. S. "Some Theorems on Instruction Illustrated with Reference to Mathematics." Theories of Learning and Instruction, N.S.S.E. Yearbook: Vol. 63. Chicago: University of Chicago Press, 1964.

Swenson, Esther J. "Organization and Generalization as Factors in Learning, Transfer, and Retroactive Inhibition." Learning Theory in School Situations, E. J. Swenson, G. L. Anderson, and C. L. Stacey. Minneapolis: University of Minnesota Press, 1949.

Thiele, C. L. "Arithmetic in the Middle Grades." The Teaching of Arithmetic, N.S.S.E. Yearbook: Vol. 50, Part II, Chicago: University of Chicago Press, 1951.

Tulving, E. and Patkau, Jeannette E. "Concurrent Effects of Contextual Constraint and Word Frequency on Immediate Recall and Learning of Verbal Material." Canadian Journal of Psychology 16: 83-95; June, 1962.

Tulving, E. "Subjective Organization in Free Recall of 'Unrelated' Words." Psychological Review 69: 344-354; July, 1962(a).

Tulving, E. "The Effect of Alphabetical Organization on Memorizing Unrelated Words." Canadian Journal of Psychology 16: 185-191; September, 1962(b).

Tulving, Endel. "Subjective Organization and Effects of Repetition in Multi-Trial Free-Recall Learning." Journal of Verbal Learning and Verbal Behavior 5: 193-197; April, 1966.

Tulving, Endel and Pearlstone, Zera. "Availability Versus Accessibility of Information in Memory for Words." Journal of Verbal Learning and Verbal Behavior 5: 381-391; August, 1966.

Underwood, B. J. "The Effect of Successive Interpolations on Retroactive and Proactive Inhibition." Psychological Monographs 13: no. 273; 1945.

Underwood, B. J. "Proactive Inhibition as a Function of Time and Degree of Prior Learning." Journal of Experimental Psychology 39: 24-34; February, 1949.

Underwood, B. J. and Hughes, R. H. "Gradiants of Generalized Verbal Responses." American Journal of Psychology 63: 422-430; July, 1950.

Underwood, Benton J. "Interference and Forgetting." Psychological Review 64: 49-60; January, 1957.

Underwood, B. J. and Schulz, R. W. "Studies of Distributed Practice: XXI, Effects of Interference from Language Habits." Journal of Experimental Psychology 62: 571-575; December, 1961.

Underwood, B. J.; Rehula, R.; and Keppel, G. "Item Selection in Paired-Associate Learning." American Journal of Psychology 75: 353-371; September, 1962.

Underwood, B. J. and Keppel, G. "Coding Processes in Verbal Learning." Journal of Verbal Learning and Verbal Behavior 1: 250-257; January, 1963.

Underwood, B. J. "Stimulus Selection in Verbal Learning." Verbal Behavior and Learning, C. N. Cofer and B. S. Musgrave (eds.) New York: Russell and Russell, 1963.

Underwood, B. J. "The Representativeness of Rote Verbal Learning." Categories of Human Learning, A. W. Melton (Ed.) New York: Academic Press, 1964.

Underwood, B. J. and Erlebacher, Adrienne H. "Studies of Coding in Verbal Learning." Psychological Monographs: General and Applied 79: No. 606; 1965.

Von Restorff, H. "Ueber die Wirkung von Bereichsbildungen in Spurenfeld," Psychol. Forsch 18: 299-342; 1933, as reported in Organizing and Memorizing: Studies in the Psychology of Learning and Teaching, S. Katona. New York: Columbia University Press, 1940.

Waters, R. H. "The Influence of Tuition upon Ideational Learning." Journal of General Psychology 1: 534-547; July-October, 1928.

Books

Anderson, R. C. and Ausubel, D. P. Readings in the Psychology of Cognition. New York: Holt, Rinehart, and Winston, 1965. 690p.

Ausubel, David P. The Psychology of Meaningful Verbal Learning. New York: Grune and Stratton, 1963. 255p.

Bartlett, F. C. Remembering: A Study in Experimental and Social Psychology. Cambridge, England: Cambridge University Press, 1932. 317p.

Cofer, C. N. and Musgrave, B. S. (eds.) Verbal Learning and Verbal Behavior. New York: McGraw-Hill, 1961. 241p.

Cofer, C. N. and Musgrave, B. S. (eds.) Verbal Behavior and Verbal Learning. New York: McGraw-Hill, 1963. 397p.

Cox, David L. Effects of Strategy Aids in Paired-Associate Learning: a Developmental Study. Unpublished Master's Thesis: Michigan State University, 1965.

Dixon, Wilfrid J. and Massey, Frank J. Introduction to Statistical Analysis. New York: McGraw-Hill, 1957. 488p.

Gagné, Robert. Conditions of Learning. New York: Holt, Rinehart and Winston, 1965.

Garrett, Henry E. Statistics in Psychology and Education. New York: Longmans, Green and Co., 1958. 478p.

Guenther, William C. Analysis of Variance. Englewood Cliffs: Prentice-Hall, 1964. 199p.

Johnson, Donald M. The Psychology of Thought and Judgment. New York: Harper and Bros., 1955. 515p.

Katona, George. Organizing and Memorizing: Studies in the Psychology of Learning and Teaching. New York: Columbia University Press, 1940. 318p.

Koffka, K. Principles of Gestalt Psychology. New York: Harcourt, Brace, 1935. 720p.

Melton, Arthur W. Categories of Human Learning. New York: Academic Press, 1964. 356p.

Miller, G. A.; Galanter, E.; and Pribram, K. H. Plans and the Structure of Behavior. New York: Holt, 1960. 226p.

Osgood, C. E. Method and Theory in Experimental Psychology. New York: Oxford University Press, 1953. 800p.

Siegel, Sidney. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill, 1956. 312p.

Swenson, E. J.; Anderson, G. L.; and Stacey, C. L. Learning Theory in School Situations. Minneapolis: University of Minnesota Press, 1949. 103p.

TenBrink, Terry. A Study of Isolation Effects During the Acquisition and Recall of Spelling Words. Unpublished Master's Thesis: Michigan State University, 1966.

Thiele, Carl Louis. The Contribution of Generalization to the Learning of the Addition Facts. New York: Bureau of Publications, Teachers College Columbia University, 1938. 84p.

Thorndike, E. L. and Lorge, I. The Teacher's Word Book of 30,000 Words. New York: Columbia University Press, 1944. 274p.

Underwood, B. J. and Schulz, R. W. Meaningfulness and Verbal Learning. Chicago: Lippincott, 1960. 430p.

Wertheimer, Max. Productive Thinking. New York: Harper and Bros., 1945. 224p.

Wertheimer, Max and Wertheimer, Michael (eds.) Productive Thinking, revised edition. New York: Harper and Bros., 1959. 302p.

Woodworth, Robert S. Experimental Psychology. New York: Henry Holt and Co., 1938. 889p.

Woodworth, Robert S. and Schlosberg, Harold. Experimental Psychology. New York: Holt, revised edition, 1954. 948p.

APPENDICES

APPENDIX A

Instructions Given at Some Point During the Experimental Session

I. General Instructions Given at the Beginning of Each Experimental Session

A. Experiment I

"This study involves learning associations among groups of three words. First, you will view a series of nine slides, each of which contains three words. The words on every slide are arranged in rows like this....(write the words 'automobile', 'table', and 'consider' on the board). These slides will be projected for very brief periods, during which time you should sit quietly and concentrate on remembering which words appear on each. Later, I will present one word from each slide, and ask you to write the other two words. In short, your task during the presentation of the first nine slides is to learn to associate the three words on each in such a way that if I present any one of them later, you will be able to write the other two.

After you have seen the entire list of three word slides, I will present a second series of slides. These slides will contain one of the words from each of the original groups of three words. As each of these words is presented, I want you to write the two words which appeared with it on the original slides. Notice that each item on your answer sheet has two blanks. Thus, if the first slide contained the word, 'table', you would write the words, 'automobile' and 'consider' in the two blanks of item one like this....(illustrate on board).

After this task, there will be a two minute rest period, at which time the assistants will check your answers. I must insist that you remain quiet during these periods. After this rest, I will present the list containing three words again. Then you will see a second set of slides containing a single word. But these words will be different from those presented on the first trial, and will also be in a different order. Thus, in the example, the word which is presented on the second trial might be the word 'consider' instead of 'table' and it might be the fifth word presented, instead of the first. You would then write the words 'automobile' and 'table' in the fifth answer blank.

When you can write the two words correctly for all nine slides twice in a row, you will be through learning the list. Your answers must be perfect, however, including spelling, so you might want to concentrate on the spelling of the words as they are shown in the original groups of three. There will be a short break at the end of each trial.

Are there any questions?

In short, your task is to learn to associate the three words on each slide in such a way that if I present any one of them, you will be able to write the other two. Is everyone ready?"

B. Experiment II

"This study involves learning associations among groups of three words. First, you will view a series of nine slides, each of which contains three words. The words on every slide will be arranged in rows like this....(write the words, 'automobile', 'table', and 'consider' on the board). These slides will be projected for very brief periods, during which time you should sit quietly and concentrate on remembering which words appear on each. Later, I will present one word from each slide, and ask you to write the other two words. In short, your task during the presentation of the first nine slides is to learn to associate the three words on each of these slides in such a way that if I present any one of them later, you will be able to write the other two.

As you might expect from this description, the list of three word slides will be followed by a second series of slides. These slides will contain one of the words from each of the original groups of three. As each of these slides is presented, I want you to write the two words which appeared with it on the original slide. You will have to write your answers quickly, however, as each slide will be shown for only a brief period.

Remember that the words which are selected from each of the original groups may be any one of the three words. Another important point is that the words will not be in the same order as the original slides containing three words. Let us suppose, for example, that the triad of words I have put on the board is the first slide that you view. After seeing it, and eight others like it, I will present the list containing single words. The fifth word on this slide might be the word 'table', in which case you would write the words 'automobile' and 'consider' in the fifth answer blank like this....(illustrate on board). On the other hand, the word selected might be the word 'consider', instead of 'table', and it might be presented third in order instead of fifth. If this were the case, you would write the words 'automobile' and 'table' in the third answer blank.

After you have written the words which you can remember for all nine slides, there will be a two minute rest period. Then we will start the cycle over again. You will see the original groups of three words, followed by the list containing one word from each group, and you will have another two minute rest. This cycle will continue until you can write the two words correctly for all nine slides twice in a row. When you can do this, you will be through learning the list. Your answers must be perfect, however, including spelling, so you might want to concentrate on the spelling of the words as they are shown in the original groups of three.

Listen carefully, because this is a helpful hint. Other studies have shown that those people who write the most words in situations like this, even if they are all incorrect, tend to learn the lists fastest. So it will be to your advantage to write whatever comes into your mind when the list of single words is presented, even if you aren't sure of the correct answer.... Are there any questions?

In short, your task is to learn to associate the three words on each slide in such a way that if I present any one of them, you will be able to write the other two.... Is everyone ready?"

II. Instructions Given Between the First Learning and First Test Trial

A. Experiment I

"We are now ready to see how much you can remember. Take out your answer sheet marked trial number one. I will give you the number of the space in which you should write your answers immediately before each slide is shown. In other words, if I say 'one' and then show a slide, you put the two words which go with the word on the slide in the space marked 'one'. Whatever you do, write your answers quickly, as you will not have much time on each slide. But please print your answers so that the scorers will be able to read them."

"Other studies have shown that those people who write the most responses in situations like this usually learn the list fastest. So even if you aren't sure of the answers, write whatever comes into your mind as each slide is shown."

B. Experiment II

"We are now ready to see how much you can remember. All of you should have the answer sheet labeled trial number one. Remember, it is to your advantage to write whatever comes into your mind, even if you aren't sure of the correct answer.... Ready?"

III. Instructions Given at the End of the First Test Trial in Both Experiment I and Experiment II

"Turn your answer sheet face down, and one of the assistants will collect it. You will now have a two-minute rest period. Please do not talk. When you have two trials in a row correct, the assistant will read your subject number. At this point, get up as quickly as you can, and go into the adjoining hall where your instructor will give you further directions."

IV. Instructions Given Immediately Prior to the Test for Long-Term Retention

"In an attempt to see how much you have remembered over the past three weeks, I am going to show you the list of single words one more time. You will not see the original slides containing three words. Rather, only the list of single words will be shown. As each word is projected, I want you to write the two words which went with it on the original slides in the appropriate places on your yellow answer sheets. As soon as I finish showing the list, I will briefly explain the purpose of the study.... Are there any questions?

It is important that all of you do the best you can, even if you have forgotten most of the words. Since those people who write the most words generally do best on these tests for retention, please write whatever comes into your mind as each slide is shown, even if you are not sure of the correct answer. This will insure that your retention score will be the highest possible.... Ready?"

V. Instructions Given Prior to the Completion of the Level of Principle Formation Questionnaire in Experiment II

. . . . "On the pages of the questionnaire which follow, you will be asked series of questions concerning what went on while you were looking at the groups of words. These questions are arranged like a program similar to the one you used in your natural science course. That is, depending on the particular way in which you answer a given question, you will be directed to another question. If your answer to the first question is 'yes', for example, the instructions tell you to go to page 2. If your answer to this same question is 'no', however, the instructions tell you to answer the second question on page 1. Whatever you do, ANSWER ONLY THOSE QUESTIONS ON THE PAGES TO WHICH YOU ARE REFERRED. In all likelihood, you will not answer all the questions on the questionnaire. Thus you should watch very carefully for your instructions regarding the next question you are to answer.

Whatever you do, read the directions at the top of each page very carefully before answering the questions on that page. Finally, please answer the questions as accurately and as honestly as you can. Remember, watch carefully for the instructions regarding which questions you are to answer, and answer only those questions to which you are referred. You may begin now."

APPENDIX B

The Level of Principle Formation Questionnaire

List________________________ Subject Number________________

Name________________________________

Student Number________________________

DO NOT OPEN UNTIL INSTRUCTED TO DO SO

EVEN NUMBERED LISTS

Directions: Check the appropriate box for each question. Then turn to the page which your answer directs you to, and answer the question on that page in the same manner. <u>Answer only those questions on the pages to which you are referred</u>!

1. Beginning with the first trial, did you attempt to find relationships between the words in <u>any</u> of the triads?

   ☐ yes - turn to page 2. (ignore question #2 below)
   ☐ no - answer question 2 below.

---

2. Despite the fact that you were not actively looking for relationships among the words in the triads, did you nevertheless discover that relationships existed on one or more of the triads?

   ☐ yes - turn to page 2
   ☐ no - turn to page 4

Consider the following two triads:

Dab	Bad	Evil
Tac	Cat	Feline

If you observe closely enough, you will see that the words in the first triad are related to each other in exactly the same way that the words in the second triad are related. (Note: "dab" is "bad" spelled backwards and "bad" is synonymous with "evil".) They might thus be said to have a "common" relationship.

While you were looking for relationships among the words in the triads on the list you just completed, did you ever discover a common relationship between words in two or more of the triads?

☐ yes - turn to page 3
☐ no - turn to page 4

1. Were you able to find a single relationship which held for all of the triads?

   ☐ yes - TURN TO PAGE 5

   ☐ no - answer question 2 below. (ignore #3)

---

2. About how many common relationships did you discover? (Indicate the approximate number of triads which shared each of the common relationships you discovered in the space provided.)

   ☐ one This relationship was common to about ________ triads.

   ☐ two The first relationship was common to about ________ triads.

   ☐ three The first relationship was common to about _______ triads.
   The second was common to about ________ triads.
   The third was common to about ________ triads.

   ☐ four or more

TURN TO PAGE 4

Directions: DO NOT TURN THE PAGE NOR REMOVE THE CLIP BEFORE READING THE DIRECTIONS CAREFULLY!

On the pages which follow, you will find the list of triads which you were presented in this study. After reading the directions, expose the pages, one at a time. Write any relationship which you found among the words in the exposed triad in the space provided to the right of each. Do this as quickly and as completely as you can.

Example: Dab Bad Evil: "bad" is "dab" spelled backwards and means about the same thing as "evil".

It is important that you write only those relationships which you discovered while going through the initial learning experience! Do not write relationships which you discover while completing this task. This would invalidate the study!

If you were not able to find a relationship between the words in a given triad while learning the list, simply write the word "none" in the space provided. Remember, write the relationship as quickly and as completely as you can. Finish each triad as it is exposed. Do not turn back to earlier pages! When you have finished, TURN TO PAGE 7. Turn the page and begin writing.

In the questionnaire which was presented to each subject, each triad was presented on an individual sheet. For purposes of convenience, however, these are depicted as follows:

1. appendage feat tale:

2. beverage whine bier:

3. food foul meet:

4. study rite reed:

5. metal steal led:

6. weather rein son:

7. group heard teem:

8. receptor ayes knows:

9. mammal dear bare:

TURN TO PAGE 7

Directions:

Keep the single relationship which you feel holds for all triads firmly in mind. Then check the boxes to the left of two statements below which best describe the relationship which you have in mind.

Example: The relationship which held for both of the triads in the example presented earlier (Dab, Bad, Evil) was that the middle word was the first word spelled backwards, and was synonymous with the third word. Thus the following two statements regarding this relationship have been properly checked below for the example.

[X] When one of the words is spelled backwards, it is identical with another word in the triad.

[ ] Two of the words have opposite meanings.

Now check two statements below which are true of the relationship which you feel holds for all triads in the list you learned earlier. CHECK THE TWO STATEMENTS WHICH BEST DESCRIBE THE RELATIONSHIP!

[ ] 1. The relationship which holds for all triads is that the words in each may be easily connected in a sentence.

[ ] 2. Two of the words in each triad have opposite meanings.

[ ] 3. Two of the words in each triad sound alike.

[ ] 4. If the spelling of one of the words in each triad were changed into a word which sounds more like it, the overall relationship between the words would be more apparent.

[ ] 5. If the spelling of one of the words in each triad were changed into a word which sounds like it, it would be identical with another word in the triad.

[ ] 6. If the spelling of two of the words in each triad were changed into words sound like them, the overall relationship between the words would be more apparent.

[ ] 7. With certain modifications, all of the words in the triad mean about the same thing.

[ ] 8. With certain modifications, all of the words in the triads are examples of a fourth categorical word.

[ ] 9. With certain modifications, two of the words in the triads are examples of the third word.

TURN TO PAGE 6

Directions: Suppose you are asked to construct a list of triads similar to the one which you have just completed. Bearing in mind the relationship which you feel holds for all of the triads, select three words from each of the lists below which conform to this relationship. In other words, construct two triads which are as similar as possible to those on the list which you have just completed. CIRCLE THE THREE WORDS IN EACH LIST. Do not look back on page 5 before completing this task!

List 1	List 2
peach	triple
two	nine
intelligent	for
cherry	three
pair	against
dumb	ate
fruit	sixty
diad	triad
plumb	number
apple	triangle

If you learned list 1, 3, 5, or 7, ANSWER QUESTION #1 BELOW. (Ignore #2)

If you learned list 2, 4, 6, or 8, ANSWER QUESTION #2 BELOW. (Ignore #1)

---

1. Briefly examine your answers on page 5. Were the two statements which you checked #6 and #9?

   - [ ] yes - turn to page 7 and follow the directions.
   - [ ] no - turn back to page 4 and follow the directions.

2. Briefly examine your answers on page 5. Were the two statements which you checked #4 and #9?

   - [ ] yes - turn to page 7 and follow the directions.
   - [ ] no - turn back to page 4 and follow the directions.

Please state any additional information which might be helpful in analyzing your performance on this test:

Other than allowing the investigator to complete his dissertation, what do you feel is the purpose of this study?

After you have completed the two questions above, you have finished your part of the study. Please hand these sheets to your instructor. I sincerely appreciate your cooperation in this study.

APPENDIX C

Table 17 through 23
Additional Analyses of the Data

Table 17. Mean number of words correctly recalled over the first three test trials for each triad (total possible = 6.00).

Position in the list	Relevant Triad	One Homonym Lists		Two-Homonym Lists	
		Mean	Rank	Mean	Rank
1	food-foul(fowl)-meet	2.962	(9)	3.047	(6)
2	metal-led(lead)-steal	4.333	(4)	3.819	(3)
3	group-heard(herd)-teem	3.743	(7)	2.714	(8)
4	beverage-whine(wine)-bier	4.809	(2)	4.266	(1)
5	study-rite(write)-reed	3.810	(6)	3.438	(5)
6	appendage-feat(feet)-tale	2.971	(8)	2.343	(9)
7	mammal-bare(bear)-dear	4.752	(3)	3.657	(4)
8	weather-rein(rain)-son	4.867	(1)	4.076	(2)
9	receptor-ayes(eyes)-knows	4.095	(5)	2.943	(7)

Table 18. Results of a one-way analysis of variance test of the differences among Ss classified at different levels of principle formation.

Dependent Variables	Sample Statistics	Level of Principle-Formation II	III	IV	F-ratio	Scheffé Test of Individual Comparisons II-III	II-IV	III-IV
A. One-Homonym Lists:								
total number words correct	$\bar{X}$ S_x^2 (n)	120.75 3,114.69 (21)	115.23 511.54 (48)	128.28 53.29 (36)	2.03	N.S.	N.S.	N.S.
number spelling distortions	$\bar{X}$ S_x^2 (n)	1.47 2.26 (21)	2.23 8.73 (48)	1.39 3.50 (36)	1.51	N.S.	N.S.	N.S.
number trials to criterion	$\bar{X}$ S_x^2 (n)	6.52 3.76 (21)	6.98 2.96 (48)	5.44 2.71 (36)	8.11**	N.S.	N.S.	**
number words correct (retention)	$\bar{X}$ S_x^2 (n)	10.43 14.26 (14)	10.93 5.38 (27)	10.65 7.04 (26)	0.16	N.S.	N.S.	N.S.
number words correct on first trial (Experiment II)	$\bar{X}$ S_x^2 (n)	7.52 11.96 (21)	7.54 9.14 (57)	8.81 7.63 (31)	1.93	N.S.	N.S.	N.S.

B. Two-Homonym Lists:								
number words correct (acquisition)	$\bar{X}$ S_x^2 (n)	112.83 397.97 (23)	104.02 398.69 (43)	123.71 122.21 (34)	12.08**	N.S.	N.S.	**
number spelling distortions (acquisition)	$\bar{X}$ S_x^2 (n)	3.48 12.69 (23)	4.21 9.07 (43)	2.18 5.97 (34)	4.44*	N.S.	N.S.	N.S.
number trials to criterion	$\bar{X}$ S_x^2 (n)	6.70 4.22 (23)	7.77 2.37 (43)	5.68 3.13 (34)	13.67**	N.S.	N.S.	**
number words correct (retention)	$\bar{X}$ S_x^2 (n)	12.57 13.65 (14)	10.29 10.91 (17)	11.41 13.61 (29)	1.55	N.S.	N.S.	N.S.
number words correct on first trial (Experiment II)	$\bar{X}$ S_x^2 (n)	6.25 12.06 (32)	6.10 9.98 (70)	7.33 4.00 (18)	1.14	N.S.	N.S.	N.S.

N.S. = not significant

* = P < 0.05
** = P < 0.01

Table 19. Results of a one-way analysis of variance test of differences among individuals classified according to the four criteria described in Table 3.

Dependent Variable	Legend	Individuals Classified According to Criteria I	II	III	IV	F-ratio
A. <u>One-Homonym Lists</u>:						
number words correct	$\bar{X}$ S_x^2 (n)	126.55 100.87 (n = 11)	127.71 37.57 (n = 7)	129.75 15.64 (n = 8)	127.91 75.39 (n = 21)	0.24 N.S.
number spelling distortions	$\bar{X}$ S_x^2 (n)	0.82 1.16 (n = 11)	1.29 4.90 (n = 7)	1.13 1.84 (n = 8)	1.52 3.96 (n = 21)	0.40 N.S.
number trials to criterion	$\bar{X}$ S_x^2 (n)	5.46 5.47 (n = 11)	5.71 2.90 (n = 7)	5.13 1.55 (n = 8)	5.57 2.96 (n = 21)	0.16 N.S.
words correct (retention)	$\bar{X}$ S_x^2 (n)	13.13 4.98 (n = 8)	10.67 21.07 (n = 6)	10.60 4.30 (n = 5)	10.67 3.81 (n = 15)	1.77 *
B. <u>Two-homonym Lists</u>:						
number words correct	$\bar{X}$ S_x^2 (n)	121.80 192.03 (13)	122.80 170.03 (13)	122.56 128.53 (9)	125.58 81.72 (12)	0.23 N.S.
number spelling distortions	$\bar{X}$ S_x^2 (n)	2.62 9.26 (13)	2.31 6.06 (13)	2.44 10.78 (9)	1.83 3.24 (12)	0.19 N.S.
number trials to criterion	$\bar{X}$ S_x^2 (n)	5.69 3.23 (13)	6.15 2.97 (13)	5.44 5.03 (9)	5.42 3.54 (12)	0.18 N.S.
words correct (retention)	$\bar{X}$ S_x^2 (n)	11.82 20.96 (11)	11.91 13.49 (11)	11.50 7.90 (6)	11.73 11.42 (11)	0.02 N.S.

N.S. = Not significant
(Alpha = 0.25)
* $0.10 < p < 0.25$

Table 20. Differences in the mean performance levels of Ss who either did or did not discover the principle according to classifications made by the Independent Judge for Experiment I.

	Legend	Total Number Correct	Trials to Criterion	Number Spelling Distortions	Total Number Intrusions
I. One Homonym Lists - Acquisition:					
(A) Ss who discovered the principle (D)	$\bar{X}$	126.95	5.70	1.79	5.91
	S_x^2	59.12	3.47	3.80	17.96
	n	(33)	(33)	(33)	(33)
(B) Ss who did not discover the principle (ND)	$\bar{X}$	117.28	7.12	2.63	10.31
	S_x^2	206.24	4.35	10.04	50.98
	n	(51)	(51)	(51)	(51)
(C) Ss who could not be classified	$\bar{X}$	128.00	6.00	0.00	4.00
	S_x^2	-	-	-	-
	n	(1)	(1)	(1)	(1)
t-tests (D vs ND)		4.00**	-3.18**	1.50	3.55**
II. Two-Homonym Lists - Acquisition:					
(A) Ss who discovered the principle (D)	$\bar{X}$	123.37	5.70	2.35	6.40
	S_x^2	141.67	3.50	7.09	22.24
	n	(43)	(43)	(43)	(43)
(B) Ss who did not discover the principle (ND)	$\bar{X}$	105.94	7.87	3.85	13.96
	S_x^2	419.94	4.46	10.21	93.34
	n	(53)	(53)	(53)	(53)
(C) Ss who could not be classified	$\bar{X}$	97.89	8.89	4.11	12.33
	S_x^2	50.74	0.74	7.61	34.75
	n	(9)	(9)	(9)	(9)
t-tests (D vs ND)		5.204**	-5.27**	2.46**	5.01**

III. <u>One-Homonym Lists - Long-Term Retention:</u>					
(A) Ss who discovered the principle (D)	$\overline{X}_2$ S_x n	11.04 5.04 (23)		1.09 0.81 (23)	3.17 2.24 (24)
(B) Ss who did not discover the principle (ND)	$\overline{X}_2$ S_x n	10.50 10.00 (32)		1.41 1.22 (32)	3.97 5.45 (32)
(C) Ss who could not be classified	$\overline{X}_2$ S_x n	9.00 -- (1)		2.00 -- (1)	2.00 -- (1)
t-tests (D vs ND)		0.75		1.14	1.54
IV. <u>Two-Homonym Lists - Long-Term Retention:</u>					
(A) Ss who discovered the principle (D)	$\overline{X}_2$ S_x n	12.08 11.85 (36)		1.36 2.12 (36)	2.28 4.55 (36)
(B) Ss who did not discover the principle (ND)	$\overline{X}_2$ S_x n	11.17 10.32 (24)		1.79 3.30 (24)	3.21 7.30 (24)
(C) Ss who could not be classified	$\overline{X}_2$ S_x n	7.50 0.00 (2)		3.00 0.00 (2)	4.00 0.00 (2)
t-tests (D vs ND)		1.04		1.01	1.49

** $p < 0.01$

Table 21. The most frequently occurring extra-list intrusions for one- and two-homonym lists.

Intrusion	Frequency of Occurrence	Relevant Triad
I. One Homonym Lists		
foot	59	appendage-tale-feet
drink	22	beverage-bier-wine (19) food-meet-fowl (3)
iron	15	metal-steal-lead
animal	9	mammal-dear-bear
learn	9	study-read-write
feed	9	food-meet-fowl
fish	9	food-meet-fowl
Total	130	
Total number extra-list intrusions = 283		
Total number different terms = 82		
N = 105		
II. Two Homonym Lists		
drink	17	beverage-bier-whine (13) food-meet-foul (4)
animal	10	mammal-dear-bare
ale	7	beverage-bier-whine
foot	7	appendage-feat-tale
leg	4	appendage-feat-tale
iron	4	metal-steal-led
Total	49	
Total number extra-list intrusions = 214		
Total number different terms = 127		
N = 100		

Table 22. One-tailed t-tests of differences in short-term retention among Ss who either did, or did not, discover the principle, with only those Ss who ultimately reached criterion included in the sample.

	Legend	Total number correct	Number trials to criterion	Number spelling distortions	Number improper plurals	Number extra-list intrusions	Number intra-list intrusions	Total number intrusions
A. One Homonym Lists:								
(A) Ss who discovered the principle (N = 42)	$\overline{X}$ S_x^2	128.67 61.06	5.07 1.82	0.95 1.71	0.67 0.72	1.10 2.62	1.33 3.01	4.05 12.34
(B) Ss who did not discover the principle (N = 40)	$\overline{X}$ S_x^2	123.58 75.33	6.08 1.97	1.38 2.50	0.60 0.96	2.63 5.68	2.13 5.34	6.73 18.61
(C) Ss who could not be classified (N = 8)	$\overline{X}$ S_x^2	122.38 98.55	6.50 3.14	3.25 6.79	1.50 2.86	2.13 1.84	3.88 8.98	10.75 32.21
t-tests (A & B)		2.80**	3.30**	1.43	-0.33	3.38**	1.92**	3.08**
B. Two-Homonym Lists:								
(A) Ss who discovered the principle (N = 40)	$\overline{X}$ S_x^2	126.98 53.31	4.88 1.50	1.66 3.19	1.22 3.47	0.81 1.12	1.73 5.87	5.11 15.18
(B) Ss who did not discover the principle (N = 24)	$\overline{X}$ S_x^2	118.92 56.60	6.33 1.28	2.25 4.54	0.63 1.72	2.13 4.81	3.54 11.22	8.54 22.52
(C) Ss who could not be classified (N = 3)	$\overline{X}$ S_x^2	126.00 570.00	5.00 3.00	1.67 1.33	0.00 0.00	1.33 5.33	4.33 12.33	7.33 22.33
t-tests (A & B)		4.23**	6.12**	1.91	-1.49	2.76**	2.50**	2.86**

* $p < 0.05$
** $p < 0.01$

Table 23. General introduction.

Tests of hypotheses 8-10 all point toward one general conclusion; namely, those Ss who discovered the principle during initial acquisition were unable to recall this principle on the test of long-term retention. The lack of a direct measure of retention of the principle thus stands as a major flaw in the design of this study. Fortunately, however, it is possible to accurately identify a small group of Ss who discovered the principle during acquisition, but who did not utilize this principle on the test of long-term retention. Those Ss presented with two-homonym lists who made one or more spelling errors on the test for long-term retention did not utilize the principle. This assertion follows from the fact that the principle which underlies those lists contains a derivative rule for spelling; namely, spell both exemplar terms as homonyms.

Ss presented two-homonym lists who discovered the principle during acquisition were therefore divided into two groups--those who made one or more spelling distortions on the test for retention (principle-not principle), and those who made no errors on the test for retention (principle-unknown). The "unknown" term in the label for the second group is indicative of the fact that Ss in this group may, or may not, have remembered the principle. The final group which was considered were those Ss who did not discover the principle during acquisition, but who nevertheless reached criterion within eight test trials (not principle-not principle).

Measures of both short-term and long-term retention were then obtained for each group on the following dependent variables: number of words correctly recalled; number of intra- and extra-list intrusions; and, number of trials to criterion. Means for each of the three groups are shown in Table 23 on the following page. The most important comparisons are those between the (principle-not principle) group and the (not principle-not principle) group. Whereas differences in performance between these two groups were substantial for measures of short-term retention, the corresponding differences for measures of long-term retention were practically nonexistant. This evidence strongly suggests that any differences which may exist between these two groups on measures of short-term retention completely disappear at the point in time when Ss who discovered the principle are unable to recall this principle.

Table 23 also depicts the results of one-tailed t-tests between the (principle-unknown) group and the (principle-not principle) group. Examination of the results of these tests indicates that whereas none of the differences are significant on measures of short-term retention, all are statistically significant for measures of long-term retention ($P < 0.01$). There is thus good reason to believe that at least some of the Ss recalled the principle, even though evidence for this assertion is post hoc in nature and therefore far from conclusive.

Table 23. One-tailed t-tests of differences among Ss in the two-homonym group who discovered the principle and who either did, or did not, make spelling errors on the test for long-term retention.

	Legend	A. Acquisition				B. Retention		
		Total number correct	Number trials to criterion	Number extra-list intrusions	Number intra-list intrusions	Total number correct	Number extra-list intrusions	Number intra-list intrusions
(A) Principle-unknown (no spelling errors)	$\bar{X}$ S_x^2 (n)	129.46 42.67 (11)	5.00 1.00 (11)	0.55 0.87 (11)	1.18 2.36 (11)	13.91 12.29 (11)	0.18 0.16 (11)	0.00 0.00 (11)
(B) Principle-not principle (at least one spelling error)	$\bar{X}$ S_x^2 (n)	126.03 55.68 (29)	5.17 1.72 (29)	0.79 1.17 (29)	2.20 7.17 (29)	10.19 11.33 (28)	0.71 0.88 (28)	0.18 0.15 (28)
(C) Not principle-not principle	$\bar{X}$ S_x^2 (n)	118.92 56.60 (24)	6.33 1.28 (24)	1.92 4.60 (24)	3.46 10.95 (24)	11.05 9.31 (20)	0.90 1.57 (20)	0.30 0.43 (20)
t-test (A vs. B)		1.34	0.44	0.67	1.36	2.46**	2.47**	2.43**

** $p < 0.01$