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This reports the effects of the number of relevant stimulus dimensions and figural versus verbal stimuli on the concept learning ability of college students. Results force a consideration of mediational variables in explaining this form of cognitive learning. A set of verbal materials analogous to a set of dimensionalized figural materials was constructed. The figural stimuli were 16 H-patterns, the combinations of values of the four binary dimensions of color (red or green), size (large or small), number (one or two), and orientation (upright or tilted); the verbal stimuli were 16 nouns, four sets of four, which had been shown to be associated with four adjectival categories: hard-white, soft-white, hard-brown, and soft-brown. Tested were two hypotheses: (1) that the difficulty of three classifications would be an inverse function of the number of relevant dimensions composing the classifications, and (2) that figural instances would be more difficult to categorize correctly than verbal instances. The hypotheses were supported, but needed to be qualified because of significant interaction. Alternative interpretations of results are discussed. (Author)

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CONCEPT LEARNING AS A FUNCTION OF THE TYPE OF MATERIAL AND TYPE OF CLASSIFICATION

By James G. Ramsay

Report from the Project on Situational Variables and Efficiency of Concept Learning
Herbert J. Klausmeier, Principal Investigator

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

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PREFACE

This Technical Report is based upon the dissertation of James Gordon Ramsay. The examining committee consisted of Professors Herbert J. Klausmeier (chairman), Nathan S. Blount, Gary A. Davis, Harold J. Fletcher, and Thomas A. Ringness.

One major program of the Wisconsin R and D Center for Cognitive Learning is Program 1 which is concerned with fundamental conditions and processes of learning. This Program consists of laboratory-type research projects, each independently concentrating on certain basic organismic or situational determinants of cognitive learning, but all attempting to provide knowledge which can be effectively utilized in the construction of instructional systems for tomorrow's schools.

Of critical importance to the field of human learning is the area of concept learning, an area in which most experimentation is designed primarily to reveal task or situational determinants of performance. Mr. Ramsay, continuing these empirical investigations, reports the effects of the number of relevant stimulus dimensions and figural versus verbal stimuli on the concept learning ability of college students. His results force a consideration of mediational variables in explaining this form of cognitive learning.

Harold J. Fletcher
Director of Program 1

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ABSTRACT

A set of verbal materials analogous to a set of dimensionalized figural materials was constructed. The figural stimuli were 16 H-patterns, the combinations of values of the four binary dimensions of color (red or green), size (large or small), number (one or two), and orientation (upright or tilted). The verbal stimuli were 16 nouns, four sets of four, which had been shown to be associated with four adjectival categories: hard-white, soft-white, hard-brown, and soft-brown. Two hypotheses were tested: (1) that the difficulty of three classifications would be an inverse function of the number of relevant dimensions composing the classifications, and (2) that figural instances would be more difficult to categorize correctly than verbal instances.

The <u>S</u>s, 36 male college students, were run individually in one of six treatments, with six <u>S</u>s randomly assigned to each group. The experiment was a 3 x 2 factorial design with three types of classification (0, 1, or 2 relevant dimensions) and two types of material (figural or verbal instances). The task was to learn to categorize the instances into four groups of four. Instances were presented sequentially and <u>S</u>s responded by pushing one of four response buttons. Correct responses were reinforced by a green feedback light over the button pushed; for a wrong response, a red light came on over the button pushed and a green light over the correct button. Presentation of instances and feedback was automated. Criterion performance was correct categorization of a block of 16 instances or 15 such blocks.

An analysis of correct responses revealed that type of classification, type of material, and the interaction of these effects were significant sources of variation ($p < .001$). Subsequent tests showed the order of difficulty of the classifications (from most to least difficult) was $0 = 1 > 2$ for the figural material and $0 > 1 = 2$ for the verbal material. In the 0 and 1 conditions, figural material was more difficult than verbal material, while in the 2 condition there was no difference between the types of material. The <u>S</u>s spent longer mean times per instance on the figural material than on the verbal material ($p < .01$). The hypotheses were thus supported, but needed to be qualified because of the significant interaction. Alternative interpretations of the results were discussed.

I
INTRODUCTION

The study of concept learning in the United States since 1950 has typically been approached through the use of three types of stimulus material. These types might be described as concrete, figural, and verbal materials. Concrete materials are frequently used where subjects (Ss) are young children and where procedures are based on the theoretical formulations of Jean Piaget. The use of figural or verbal materials would also seem to be determined, to some extent, by the theoretical orientation of the experimenter. Thus, experimenters interested in describing quantitatively and in manipulating the amount of information transmitted by various instances tend to use figural stimuli generated by combinations of values of binary dimensions (e.g., Bulgarella & Archer, 1962). The use of the term "information" in this context is derived from the information theory of Shannon and Weaver (1949).

Underwood and Richardson (1956a), on the other hand, developed a set of verbal materials to study concept learning as a form of verbal learning. It is the comparison of dimensionalized figural material and the verbal materials generated by Underwood and Richardson to which the present study is addressed.

Arnstine (1967) has suggested that the gathering of evidence for theories of learning has proceeded in the following manner. Suppose you are asked to judge which of two theories about the taste of water is correct. One theorist who says it is salty gives as evidence samples of water which he has taken from the ocean for you to taste. The other theorist gives samples of lake water as his evidence. You, as one naive about the taste of water, ask for more evidence and the first theorist continued to take samples from the ocean, the second from the lakes. Clearly, as long as evidence is gathered in this manner, your choice is an arbitrary one. Similarly, Arnstine argues, "...the 'facts' of human behavior are drawn from different wells and are quite reasonably fitting for the different theoretical buckets which contain them [p. 51]."

The description just cited seems to be particularly relevant to the study of concept learning. It may be that evidence drawn from studies where dimensionalized figural material has been used has little relationship to evidence from studies with verbal material. Where such kinds of evidence are used only to facilitate the design of further experiments, the matter may not be a crucial one. But when the evidence is used to change educational practice, the type of material used becomes very relevant. This point can be clarified by a further example. Bruner, Goodnow and Austin (1956) conducted a series of experiments using dimensionalized figural material. Later, Bruner (1960) produced a highly influential set of statements about how the education of children should be properly undertaken. He emphasized discovery learning. It is not coincidental that this approach closely parallels the selection paradigm developed by Bruner et al. in research on concept learning.

The move from evidence based on dimensionalized figural material to revision of curricula may or may not be a good one. It seems reasonable to assume that most concept learning in the classroom is closely linked with verbal media. Whether or not Brunner's evidence applies to such media can be questioned. Ausubel (1961), for one, has been critical of the approach advocated by Bruner. What seems to be needed is research in which a verbal analogue to dimensionalized figural materials is developed so that variables shown to be effective with figural material can be tested on verbal material. Until such research is initiated, the study of concept learning will produce evidence limited to the type of material used in the particular experiments.

PURPOSES AND HYPOTHESIS OF THE STUDY

The purposes of the study were (1) to construct from the Underwood and Richardson word list a set of verbal materials analogous to dimensionalized figural materials; (2) to study concept learning as a function of type of material and type of classification.

Two hypotheses were tested. The first was that the rank order of difficulty in learning to classify 16 instances into four categories would be inversely related to the number of relevant dimensions used to determine the type of classification. Thus, it was predicted that zero relevant dimensions would be a more difficult classification to learn than one relevant dimension, and the latter would be more difficult than two relevant dimensions. The second hypotheses was that learning to classify figural instances would be more difficult than learning to classify verbal instances. Difficulty was defined as the number of errors made to criterion.

METHOD

Thirty-six volunteer Ss, all males, participated in the experiment. The figural material consisted of 16 H-patterns which varied on four binary dimensions. The Underwood and Richardson (1956a) list and the Mayzner and Tresselt (1961) judgmental procedure were used to obtain an analogous set of 16 verbal instances.

An S's task was, on observing an instance, to identify its membership in one of four categories by pushing one of four reponse buttons. Instances and feedback information were presented by automated apparatus through a procedure described by Archer, Bourne, and Brown (1955). The experiment was conducted in the laboratory facilities of the Wisconsin R & D Center.

Type of material, figural or verbal, was one of the independent variables used in the study. The second was type of classification. The three levels of this variable were identified in terms of number of dimensions relevant to a particular category of instances: 2, 1, or 0.

SIGNIFICANCE OF THE STUDY

To the author's knowledge, the comparison of dimensionalized materials and analogous verbal materials identified from associational dimensions had not been made before this study was conducted. It was thus the first step toward more extensive research where variables shown to be effective with figural materials can be applied to verbal materials. Since most concept learning in the schools takes place with verbal media, the step is an important one.

II
REVIEW OF RELATED LITERATURE

Two search procedures were used for this review. First, listings from Psychological Abstracts (Jan., 1950 - Jan., 1967), Concept Learning and Problem Solving: A Bibliography, 1950–1964 (Klausmeier, Davis, Ramsay, Fredrick, & Davies, 1965) and Tasks Employed in Concept Identification and Problem Solving Studies (Davies, Cooper, Davis, & Stewart, 1965) were consulted. Secondly, bibliographies of articles and books related to concept learning were scanned.

One area not covered by this review is the approach to concept learning developed by Jean Piaget. As Bourne (1966) has pointed out, Piaget's influence is appreciable, but his unique methods, his broad domain of study, and his divergence from conventional American theory make it difficult to compare his theory and data to that of American psychologists. Similarly, there is a vast literature on verbal learning, but much of it is not relevant to the problems posed in the present study. Thus, only those studies of verbal learning (1) which are specifically concerned with concept learning, (2) which present experimental paradigms comparable to the one used in the present study, or (3) which have theoretical relevance for the present study have been included.

TYPE OF CLASSIFICATION

One dictionary definition of "classification" is "...arrangement according to some systematic division into classes or groups [Websters New World Dictionary, 1966]." This definition is acceptable for this study. The term will be used synonomously with "categorization." The terms used to describe the result of a classification will be "sets of instances," "groups," "categories," and "concepts."

Descriptions of Classifications

Shepard, Hovland, and Jenkins (1961) gave a thorough description of the ways in which instances could be classified, and tested the difficulty of different classifications. They defined a classification as a grouping of a given set of stimuli into two or more mutually exclusive and exhaustive classes.

The stimuli which Shepard, Hovland and Jenkins used for explanatory purposes were eight unique instances, the combinations of values of the three binary dimensions of size (large or small), color (black or white), and shape (triangle or square). Their description can be applied to any set of eight instances based on three binary dimensions, but is limited to types of classifications which result in the partitioning of the eight instances into two sets of four instances each. The authors identified six types of classifications which are illustrated as C–I through C–VI in Figure 1.

Though the present study used sixteen instances (four sets of four), some of the Shepard et al. classifications are comparable to the classifications used in the present study, in which either two relevant dimensions (R–2), one relevant dimension (R–1), or zero relevant dimensions (R–0) were used to group instances. Table 1 is an illustration, in binary notation, of C–I and C–VI of the Shepard, Hovland and Jenkins study and groups R–2, R–1, and R–0 of the present study. Each row of digits within a set represents an instance; each column of digits within a set represents a dimension which can take one of two values for a given instance.

If the first binary digit is dropped from each instance in R–2, sets W and X and sets Y and Z of the R–2 display become identical to sets A and B of C–I. Similarity also exists between C–VI and R–0. An inspection of the columns of binary digits in each of the sets of instances of C–VI and R–0 reveals that each value of every dimension is represented equally often in a given set of instances. In both C–VI and R–0 there are thus no consistent cues to aid in categorizing the instances into their appropriate sets. There is no obvious comparison

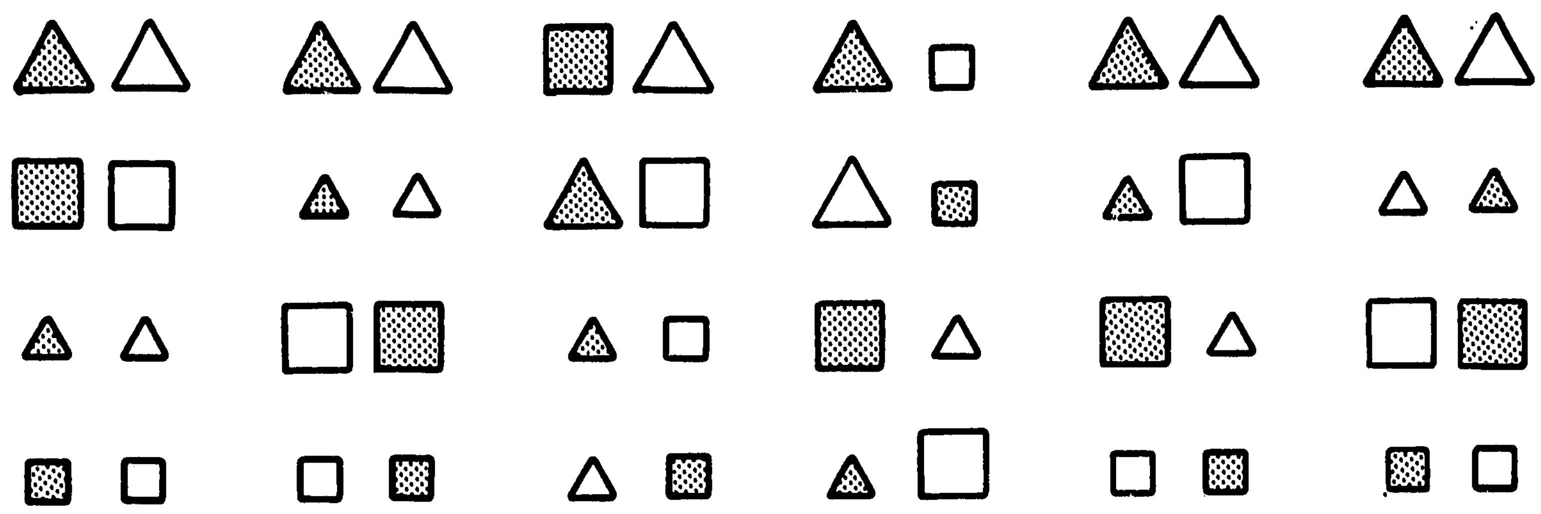


Figure 1. Six Types of Classifications (from Shepard, Hovland, & Jenkins, 1961)

TABLE 1. A comparison of Shepard, Hovland and Jenkins' Type I and Type VI Classifications with the Classifications in the Present Study Termed Two, One and Zero Relevant Dimensions

C–1		C–VI	
A	B	A	B
000	100	000	100
001	101	110	010
010	110	101	001
011	111	011	111

R–2				R–1				R–0			
W	X	Y	Z	W	X	Y	Z	W	X	Y	Z
0000	0100	1000	1100	0000	0100	0001	1000	0000	0001	0010	0011
0001	0101	1001	1101	0011	0111	0010	1011	1001	1011	1000	1010
0010	0110	1010	1110	1011	1101	0101	1100	0110	0100	0111	0101
0011	0111	1011	1111	1010	1110	0110	1111	1111	1110	1101	1100

of R–1 to any of the classifications described by Shepard, Hovland and Jenkins. It can be noted that dropping the first digit from instances in sets W and X and the last digit from sets Y and Z in R–1 makes W and X, and Y and Z, identical to A and B of C–1. But, the shift from dropping the first to dropping the last digit in accomplishing this equivalence indicates that the relationship between R–1 and C–I is more complex than the relationship between R–2 and C–I.

Shepard, Hovland and Jenkins found, under a variety of different conditions, a consistent rank-order of difficulty of learning the classifications. From easy to difficult, the order of classifications was: C–I; C–II; C–III = C–IV = C–V; C–VI. Shepard and Chang (1963) found a nearly identical rank order of difficulty using colors obtained from a Munsell color chart. Davis and Bourne (1965) found C–I was easiest to learn, C–VI hardest, with C–II, C–III, C–IV and C–V of intermediate difficulty. These findings suggest that the difficulty of the learning of classifications used in the present study would be R–2 (easiest), R–0 (most difficult), and R–1 (intermediate difficulty).

Several authors (e.g., Hunt & Hovland, 1960; Hunt, 1962; Bruner et al., 1956) have described classifications of instances according to conjunctive and disjunctive rules. Conjunction corresponds to the intersection of sets, the verbal connective being "and" as in the concept "red and circle." Disjunction corresponds to the union of sets, the verbal connective being "or" as in "red or circle." Disjunction can be further described as inclusive or exclusive. An example of the former is "red or circle or both;" an example of the latter is "red or circle but not both."

It has been shown that concepts based on conjunctive rules are easier to learn than those based on disjunctive rules (Neisser & Weene, 1962; Conant & Trabasso, 1964; Haygood & Bourne, 1965). In the Haygood and Bourne study it was also shown that difficulty was a direct function of length of rule. The increase in difficulty due to disjunction and length of rule may account for Shepard, Hovland, and Jenkins' results. To reconsider the classifications illustrated in Figure 1, let v stand for disjunction; & stand for conjunction; and the letters W, B, L, Sm, T, and Sq stand for white, black, large, small, triangle, and square, respectively. The six classifications C—I through C—VI have been expressed in symbolic form in Table 2. C—I is based on shorter rules than C—VI and there is a regular increase in the number of disjunctions from C—I to C—VI. Although the rules needed to describe the classifications in the present study are longer due to the introduction of a fourth dimension, it can be demonstrated that a similar increase in length of rule and number of disjunctions occurs from R—2 to R—1 to R—0. A corresponding increase in difficulty for these latter classifications could thus be expected.

TABLE 2. Shepard, Hovland and Jenkins' (1961) Types of Classifications in Symbolic Notation

Classification	SET A
I	(B)
II	(B&T)v(W&Sq)
III	(B&L)v(T&Sm)
IV	(B&L)vT&[(L&W)v(Sm&B)]
V	(B&T)vSq&[(B&L)v(W&Sm)]
VI	T&[(B&L)v(W&Sm)]vSq&[(W&L)v(B&Sm)]
	SET B
I	(W)
II	(W&T)v(B&Sq)
III	(W&L)v(Sq&Sm)
IV	(W&Sm)vSq&[(Sm&B)v(L&W)]
V	(W&T)vSq&[(W&L)v(B&Sm)]
VI	T&[(W&L)v(B&Sm)]vSq&[(B&L)v(W&Sm)]

Classifications and Similarity

Shepard, Hovland and Jenkins (1961) suggested that it would surely be easier to learn to make one response to four horses and another to four dogs than to make the first response to two horses and two dogs and the second to the remaining two horses and two dogs. It has been shown for concrete materials (Baum, 1954; Buss, 1950), for figural materials (Oseas & Underwood, 1952) and for verbal materials (Underwood, 1957; Neuman, 1957) that as instances of different concepts being learned simultaneously become more similar, the learning of the correct placement of instances becomes more difficult. Underwood (1957) constructed three lists of nouns which varied on intralist similarity. Each list was a set of 16 nouns, four instances each for the concepts round, small, white and soft. In List 1, instances of each concept had no associations with other concepts. In List 2, an instance of a given concept also had an association with one other concept (e.g., "round" was the appropriate response for the noun "bean," but "bean" also had an association with the concept "small"). Instances on List 3 had an average of 1.9 associations with concepts other than the appropriate one. Underwood found concepts for List 1 to be significantly easier to learn than those for Lists 2 or 3.

In the present study, intralist similarity cannot be said to vary since the same instances are used in each of three classifications. However, similarity between instances of different concepts does vary inversely with number of relevant dimensions, and based upon the research cited above, the prediction that increasing the number of relevant dimensions will facilitate performance is a tenable one.

TYPE OF MATERIAL

In this section, research on concept learning conducted with figural and verbal instances will be discussed and implications of the theoretical construct of mediation will be considered.

Figural Material

Hull (1920) defined a concept as a common response to dissimilar stimuli having common elements. A problem with this definition may occur if it is applied in its narrowest context. The definition suggests that the proper study of concept learning is limited to the construction of instances of concepts which have immediately observable commonalities. Hull's (1920) initiation of the study of concept learning was a classic experiment and certainly a contribution, but may have set a precedent for the use of figural materials. Smoke's (1933) study of the relative contributions of positive and negative instances to concept learning also employed figural material. Gibson in 1940 proposed a theory of verbal learning which stressed the importance of stimulus generalization, a construct which came to play an important role in considerations of concept learning (e.g., Buss, 1950; Baum, 1954; Shepard, 1957; Shepard, 1958; Shepard & Chang, 1963). It is somewhat ironic that Gibson's own tests of her theory were conducted with figural material (Underwood, 1961). Until as late as 1956, when Underwood and Richardson published verbal materials for use in studying concept learning, the main materials used were figural.

The use of figural material does have advantages. One is that such material provides the same kind of control over extra-experimental factors that nonsense syllables do in the study of verbal learning. Dimensionalizing the materials adds a further element of control since, with this operation, a finite population of instances is generated which can be divided unambiguously into positive and negative instances. Outside of the laboratory, such control over instances is unattainable. Shipstone (1960) has suggested that this is the very reason why dimensionalized figural material has limitations, since ambiguity is characteristic of most situations in the real world.

In two studies (Ramsay, 1965; Fredrick, 1965), the effects of figural and verbal instances on the identification of concepts were tested. The task was what Bourne (1966) has described as a selection paradigm. The figural instances were the 64 combinations of six binary dimensions. The verbal instances had the values of dimensions typed in words on the cards rather than represented directly. Thus, a figural instance might have shown two small red spotted circles with one border surrounding them, while the comparable verbal instance gave this same information in words. Ramsay found that figural instances led to significantly shorter times to criterion. Fredrick, who used the figural instances as a practice task, found no differences between these instances and the verbal ones.

These studies, however, do not appear to capitalize on the inherent differences between the two types of material. Had the verbal instances been written in Swahili rather than English, non-Swahili speaking Ss could still have learned the appropriate classification into positive and negative instances since the words themselves could be regarded as configurations giving rise to observable cues consistently associated with positive and negative instances. Another approach to the construction of verbal material is to relate the instances and concepts by association value rather than by direct symbolization of figural material.

Verbal Material

Underwood and Richardson (1956a) developed verbal concept learning materials consisting of a list of nouns and a set of adjectival categories associated with the nouns. The adjectival categories were based on sensory impressions (e.g., round, smelly, yellow, rough) and the nouns stood for concrete objects (e.g., brick, pill, cabin, whale). Each noun was presented to a sample of 153 college students who were given four seconds to respond with the first sensory impression that they thought of to describe the noun.

Data were tabulated in terms of the percent of Ss who gave the same adjectival response for a particular noun. For example, for the stimulus word "apple," 67% of the Ss responded with the adjective "red," 19% with "round," and 5% with "sweet." The published table was a list of the 213 nouns with entries after each noun for the adjectives which 5% or more of the Ss gave as a description of the noun. There were 40 adjectives which met this 5% criterion. The adjectives were considered to be concepts and the subsets of nouns associated with the adjectives, instances of those concepts. In the typical experiment, S was presented with a list of several instances of different concepts and learned to respond with the correct concept for each instance.

With the material, sets of instances with different mean association values for the same concept could be constructed. These means have been termed levels of a variable called "dominance level" (Underwood & Richardson, 1956b). It has been shown that ease of concept learning is a direct function of dominance level (Underwood & Richardson, 1956b; Coleman, 1964). Other factors which have been shown to improve performance have been increasing the associative rank of instances (Mednick & Halpern, 1962), increasing the variance of the dominance values of a set of instances (Freedman & Mednick, 1958), increasing the specificity with which Ss are instructed (Underwood & Richardson, 1956b), and decreasing the degree of overlap of associations among instances of different concepts (Underwood, 1957).

Runquist and Hutt (1961) selected from the Underwood and Richardson materials four verbal instances each for the concepts round, soft, sharp, and slimy and made comparable sets of pictorial instances. For example, the corresponding pictorial instances for the verbal instance "bed" was a line drawing of a bed. Both the word "bed" and the picture bed were instances of the concept "soft." Two forms of each pictorial instance were constructed, one which emphasized the characteristic that made the instance an exemplar of the concept, and one in which the characteristic was not emphasized. The emphasized form showed a "soft and billowy" bed while the other form showed a bed which looked "like an army cot."

Subjects were run individually and in only one condition, seeing each of the 16 instances 15 times, the set of 16 instances being shuffled after each block. The Ss were instructed to respond verbally with a descriptive word within three seconds of the presentation of each instance. Correct responses received a "right" from the experimenter (E). Sixty Ss were run in a 3 x 4 factorial design with three levels of type of material (Verbal, Picture Dominant, or Picture Nondominant) and four grade levels (Ss were freshmen, sophomores, juniors or seniors in high school). Both main effects were statistically significant while the interaction was not. Verbal instances resulted in a significantly higher mean number correct responses than the Picture Dominant instances ($p < .01$) and Picture Dominant instances resulted in a significantly higher mean number correct responses than the Picture Nondominant instances ($p < .02$).

Runquist and Hutt offered two interpretations for the results. The first was that verbal instances resulted in higher performance because the stimuli and responses in the verbal condition were given in the same medium. This stimulus-response compatibility allowed the highly likely associations between instances and concepts to be used without Ss necessarily forming "an image" of the word as an object when he responded. The second interpretation, and a more plausible one according to the authors, was that three of the concepts used in the study (sharp, soft, slimy) were tactual rather than visual, that pictorial instances of these concepts would tend to be responded to with visual rather than tactual terms, and that the visual descriptive responses would tend to interfere with the responses designated as the correct ones.

Both interpretations are subject to criticism. It could be argued that the visual presentations of words and pictures were the same medium rather than different media. Also, there was the omission of a simple test which might have given support for the second interpretation. The test would have been to compare number of correct responses for "round" (a visual concept) with number of correct responses for each of the tactual concepts. According to the second interpretation it could be predicted that the number of correct responses for the visual concept would be greater than for the other concepts. Although this result could not have been construed as conclusive evidence, it would have supported the interpretation.

In the Underwood and Richardson (1956a) scaling technique, the dominance value for a concept and an instance of that concept was the percentage of Ss who responded to the instance with the concept. With this approach there seems to be the implicit assumption that different dominance values of two concepts which share the same instance reflect a hierarchy of responses for a particular S. For example, because more Ss responded with "red" to the stimulus word "apple" than with "sweet," "red" is inferred to be the more highly dominant response for the average S. This approach obscures individual differences. Clearly, for those Ss who responded with "sweet" to "apple," "sweet" is in Underwood and Richardson's terms the dominant response for these Ss.

The judgmental technique of Mayzner and Tresselt (1961) has a certain advantage to Underwood and Richardson's associational method. Mayzner and Tresselt's Ss were presented with a list of 300 nouns and judged the inclusion of the nouns in none, one, or more than one of six adjectival categories. While this approach limited the number of concepts for use in latter experiments, it did allow Ss to respond with more than one concept to a particular instance, rather than being limited to one concept per instance as in the Underwood and Richardson study.

Mediational Considerations

Kendler (1961) and her associates have suggested that S's covert response may serve a mediating function. This hypothesis was used to clarify data on the effects of reversal and nonreversal shifts. In the task typically used by Kendler, the stimulus material was figural and varied on binary dimensions. Initially instances were placed into a correct category depending on one value of one dimension. In the nonreversal shift, correct categorization became based on one value of another dimension, while in the reversal shift situation correct categorization became based on the other value of the relevant dimension of the initial task. If the relevant dimension in addition to the relevant value of that dimension was reinforced, the reinforced dimension could serve as a mediator, in which case it could be predicted that the reversal shift would be easier to learn than the nonreversal shift. It was shown that rats and young children performed better on the nonreversal shift (Kelleher, 1956; Kendler, Kendler, & Wells, 1960), while older human Ss performed better on the reversal shift (Buss, 1953; Kendler & D'Amato, 1955; Harrow & Friedman, 1958). These data were considered to support the hypothesis that the relevant dimension served as a mediator and that the availability of the mediator facilitated performance.

If relevant dimensions serve a mediating function for more mature Ss, the college students used in the present study might perform better on classifications with more relevant dimensions. In the R—0 condition, no such mediators could be used, while the R—2 condition would allow two dimensions to serve as mediators.

If Ss in the verbal condition were able to arrange the verbal instances into syntactical units, these units might also serve a mediating function. For example, the disparate verbal instances "cork" and "enamel" have no common descriptive adjective in the Underwood and Richardson tabulations. However, an S who sees that both instances are categorized under response button 4 might form a mediating sentence like "Enamel the four corks" so that upon later presentations of the instances, the mediator would help him categorize both instances correctly. No such easily formed mediational units would seem to be available for the disparate figural instances "one large green upright H" and "two small red tilted H's." Verbal mediators like "Enamel the four corks" are related to a consideration of memory load. Miller (1956) has suggested that a considerable amount of information can be stored as long as it is recoded into a relatively small number of symbols. The implementation of verbal mediators would allow information to be recoded and to be recalled in what Miller has termed "chunks." The subsequent reduction of the number of units to be recalled would tend to facilitate performance. If it is assumed that the verbal instances lend themselves more easily to such recoding it could be predicted that Ss in the verbal condition would have a better chance of correctly categorizing instances.

SUMMARY

It has been suggested: (1) that the three types of classifications used in the present study are in some ways comparable to those described by Shepard, Hovland, and Jenkins (1961); (2) that based on the results of Shepard, Hovland and Jenkins and others who have used the same classifications, the rank order of difficulty of the three types of classifications used in the present study could be expected to be R—0 (most difficult), R—1 (intermediate difficulty), R—2 (easiest); (3) that the increasing complexity and length of rules needed to describe the classifications symbolically are bases for explaining why this rank order might be obtained; (4) that decreasing the number of relevant dimensions increases the similarity between instances of different concepts and increases the difficulty; (5) that increasing the number of relevant dimensions may allow these dimensions to serve as mediators and thus to facilitate performance. These points allow the firm prediction that the rank order of difficulty for the three classifications will be R—0, R—1, R—2. Further, it was suggested that Ss in the verbal condition would have an advantage in using verbal mediators as mnemonic devices. Such mediators would allow these Ss to reduce memory load by "chunking" the instances into units which were more easily recallable. It is thus predicted that the figural condition would be more difficult than the verbal condition.

III
IDENTIFICATION OF ASSOCIATIONAL NORMS

Underwood (1957) characterized the manipulation of similarity in figural materials as centering on commonalities of physical characteristics, while in his study of verbal concept learning he focused on similarity as a function of commonalities of descriptive characteristics of nouns. Underwood's comparison was used as the basis for creating analogous figural and verbal materials in the present study. In its simplest form the analogy can be made between figures which all have the color green in common and nouns which all have the association "white" in common. Further, just as figural stimuli can vary along a physical dimension like color, so can verbal stimuli vary along an associational dimension of color. Finally, where sets of figural stimuli can be categorized with respect to relevant physical dimensions, so can sets of verbal stimuli be categorized with respect to relevant associational dimensions.

The Underwood and Richardson (1956a) list provided the initial source for verbal instances. Many of the forty adjectives on the list could be considered to be values or dimensions. Some of these dimensions and values are size (small, big), hardness (hard, soft), texture (slimy, smooth, fuzzy, sticky, rough), weight (light, heavy), and taste (sweet, sour-bitter). Ideally, the set of verbal instances used in the present study would have been associated with values on four such dimensions. However, it was impossible to identify 16 verbal instances, each of which was associated with a unique combination of values of four binary dimensions as was possible with the figural material. Such a procedure was prohibitive because of incompatible joint associations. For example, a noun described as red, sweet, and juicy was not square. In a more general sense, it would appear that associational dimensions in the English language are not orthogonal. Given a noun for which some values of associational dimensions are present, the presence of other values of other dimensions can, to some extent, be predicted.

The next step was an attempt to identify verbal instances of the four categories based on the conjunction of values of two binary dimensions. The four most likely categories were: hard-white, soft-white, hard-brown and soft-brown. Even at this reduced level of complexity, however, the Underwood and Richardson (1956a) list of 213 nouns was not sufficient to obtain four instances for each of the four categories so recourse was made to the Mayzner and Tresselt (1961) procedure.

Underwood and Richardson gave 213 nouns to 153 Ss and identified 40 adjectives used to describe the nouns. Mayzner and Tresselt took six of these adjectives and obtained adjectival descriptions from 100 Ss for each of 300 nouns (the 213 used by Underwood and Richardson plus 67 more). In the present study three of Mayzner and Tresselt's adjectives (white, hard, small) and three other adjectives from Underwood and Richardson's material which had not been used by Mayzner and Tresselt (brown, soft, big) were listed as headings of six columns of a response sheet, and 24 nouns were listed as headings of rows on the response sheet. Sixteen of these nouns were common to the Underwood and Richardson and the Mayzner and Tresselt lists; the remaining eight were identified by the present author as possible instances for the categories hard-brown and soft-brown, the two categories where there were missing instances. The twenty-four words were:

acorn	closet**	ivory*	pottery
beer bottle	cork*	linen*	rabbit*
bread*	enamel*	loam	salt*
bronze	garlic**	mahogany	sheep*
chamois*	gavel	mink	skull*
chestnut*	grass**	moccasin*	snail**

The starred nouns were taken from the Underwood and Richardson— Mayzner and Tresselt list. Those with two stars were selected randomly from the Underwood and Richardson list as buffer items which had no associations with hard, soft, brown or white. The unstarred nouns were those identified by the present author.

Twenty volunteer Ss, 13 males and 7 females from the staff of the Wisconsin R & D Center, responded to the nouns by checking those adjectives which could be used to describe a given noun. These data and the data from the Underwood and Richardson and the Mayzner and Tresselt lists all took the same form. In each case, the percent of Ss who responded to a given noun with a given descriptive adjective was tabulated. These percent response frequencies are an estimate of the degree to which the adjective would be elicited upon presentation of the noun. In a more general sense, the percentages are an indication of the strength of association between an instance (noun) and a concept or category response (adjective). In Table 3 is presented the percent of Ss who responded to a given noun with white, small, or hard, the three adjectives used in each of the three studies. The entries in this table were used to calculate Pearson Product-Moment correlation coefficients between association values found in the present study and those found by Underwood and Richardson and Mayzner and Tresselt. For example, in Table 4 are the words and values used to calculate the degree of relationship between the results of Mayzner and Tresselt and those of the present study for the concept "white."

In order to avoid spurious inflation of the correlation coefficient due to association values of zero, only those words which had values of 5 or more were used. Instances like "grass" were not included in Table 4 since neither in the present study nor in Mayzner and Tresselt's data was grass associated with the category "white." Adding words like grass with zero association values would have increased the value of the correlation since it would have added a perfectly correlated pair of scores to the table, but would have obscured the actual relationship. Tables similar to Table 4 were constructed for nouns associated with small and hard. All of these correlation coefficients are given in Table 5.

Association values had been obtained for the nouns identified by the present author. These values are presented in Table 6. Since these words did not appear on either the Underwood and Richardson or the Mayzner and Tresselt list, no correlation could be run using them. From the size of the correlations which were run, however, it was assumed that the values obtained for the nouns in Table 6 were reasonable estimates of the values which would have been obtained if the nouns had, in fact, been used in the other two studies. From the nouns in Table 6, acorn, bronze and mahogany were selected as instances of the concept hard-brown, and mink was selected as an instance

TABLE 3. Percent of Ss that used a Given Adjective to Describe a Given Noun: Data from Ramsay (R), Underwood and Richardson (U & R), and Mayzner and Tresselt (M & T)

	White			Small			Hard		
	R	U&R	M&T	R	U&R	M&T	R	U&R	M&T
bread	90	35	55	5	0	7	10	0	7
chamois	5	0	9	5	0	11	0	0	3
chestnut	0	0	0	70	9	56	80	18	57
closet	0	0	5	40	24	33	0	0	5
cork	0	0	1	50	0	40	5	0	10
enamel	40	28	40	0	0	1	80	20	65
garlic	40	0	10	35	0	20	5	0	4
grass	0	0	1	0	0	7	0	0	0
ivory	95	65	95	0	0	1	80	14	50
linen	85	59	86	0	0	1	0	0	0
moccasin	5	0	0	30	0	18	0	0	1
rabbit	45	25	41	35	6	54	0	0	1
salt	100	53	66	20	0	33	35	7	11
sheep	85	23	75	5	0	6	0	0	0
skull	95	25	22	10	0	5	95	36	71
snail	0	0	2	85	42	72	10	0	10

TABLE 4. Correlation Between Association Values found by Ramsay and by Mayzner and Tresselt for the Concept White

Noun	Percent of Ss Who Responded with "White" to a Given Noun: Ramsay		Mayzner and Tresselt
bread	90		55
chamois	5		9
enamel	40		40
garlic	40		10
ivory	95		65
linen	85	r = .72	59
rabbit	45		41
salt	100		66
sheep	85		75
skull	95		22

TABLE 5. Pearson Product-Moment Correlation Coefficients for Associational Value found by Underwood and Richardson (U & R), Mayzner and Tresselt (M & T), and Ramsay

Adjective	Source for Values Correlated	Pearson
white	U & R - Ramsay	.49
	M & T - Ramsay	.72
small	U & R - Ramsay	.60
	M & T - Ramsay	.90
hard	U & R - Ramsay	.81
	M & T - Ramsay	.97

of the concept soft-brown. These four instances, plus 12 more which had been selected from the Underwood and Richardson list, are presented in Table 7.

TABLE 6. Association Values for Instances Hypothesized to Fit the Categories Hard-Brown and Soft-Brown

noun	white	brown	small	big	hard	soft
acorn	0	85	85	0	95	0
beer bottle	0	85	5	5	50	0
bronze	0	50	0	5	65	15
gavel	0	40	25	0	85	0
loam	0	45	0	5	0	50
mahogany	0	85	0	15	85	15
mink	5	60	30	0	0	80
pottery	5	20	15	5	85	0

TABLE 7. The 16 Verbal Instances

Type of Classification	Category 1	Category 2	Category 3	Category 4
R—2	(white-hard)	(white-soft)	(brown-hard)	(brown-soft)
	bone	rabbit	gavel	cork
	salt	linen	chestnut	mink
	enamel	bread	acorn	chamois
	skull	sheep	bronze	moccasin
R—1	(white)	(brown)	(hard)	(soft)
	bone	gavel	salt	rabbit
	skull	bronze	enamel	sheep
	linen	mink	chestnut	cork
	bread	chamois	acorn	moccasin
R—0	(-----)	(-----)	(-----)	(-----)
	bone	skull	salt	enamel
	bread	sheep	linen	rabbit
	bronze	acorn	gavel	chestnut
	chamois	moccasin	mink	cork

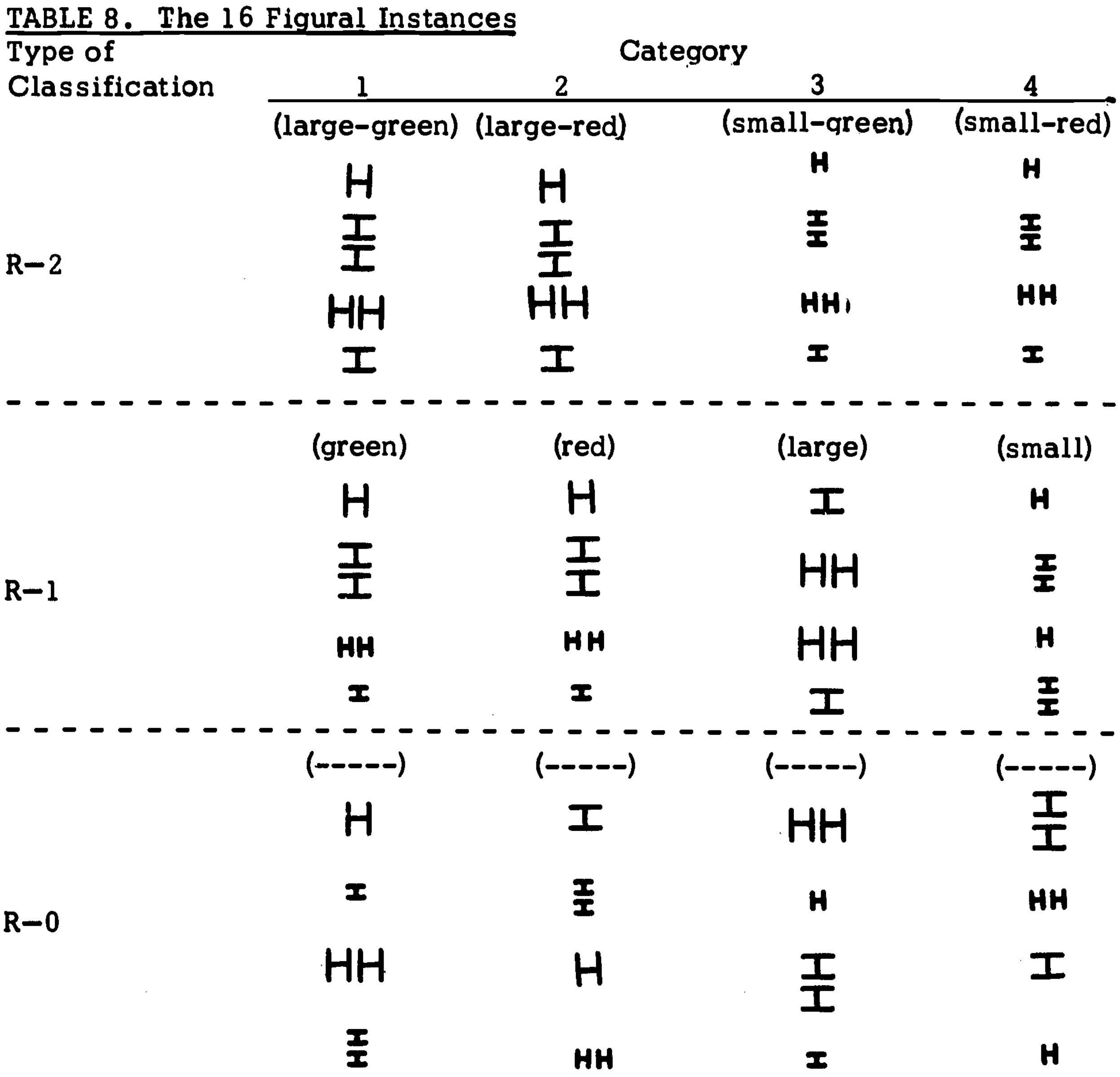
IV
METHOD

In the summary section of Chapter II, it was suggested that two predictions might be made with regard to type of classification and type of material: (1) that the rank order of difficulty of learning the three types of classifications would be: R–0, the most difficult classification followed by R–1, with R–2 the easiest classification, and (2) that learning with the figural material would be more difficult than learning with the verbal material. The method by which these predictions were put to empirical test is the content of this chapter. The chapter consists of four sections which are: Experimental Material, Subjects, Experimental Procedure, and Experimental Design.

EXPERIMENTAL MATERIAL

The 16 figural instances used in the stu were H-patterns which varied as to number (one or two), size (large or small), color (r or green), and orientation (upright or tilted Each instance was constructed, photograpl on color slides, and mounted in 2 in. x 2 i slide frames. These slides were projected a 12 in. x 15 in. rear-projection screen. large upright patterns were 2 1/2 in. tall w the small, upright patterns were 1 1/4 in. Variations in values of each dimension wer easily discriminable. The instances are re sented in Table 8. The 16 verbal instance:

TABLE 8. The 16 Figural Instances



were presented in Table 7 of the last chapter. Each was typed on mimeograph stencil, cut out, and mounted on 2 x 2 in. slides. The letters in the projected words were white, 3/4 high, in lower case type.

The presentation of the slides and of feedback information was fully automated. The apparatus, which has been described in detail elsewhere (Davis, 1968), consisted of three units: a four channel response unit, a tape reader, and a Kodak Carousel slide projector. The response unit housed the electronic circuitry, four response buttons, eight feedback lights (a red and a green light over each button), and the projection screen. A continuous loop of tape was punched with the correct responses and fed through the tape reader. This unit, in conjunction with the response unit, controlled the feedback lights, while the response unit controlled the slide advance.

The function of the apparatus can be made clear by the following sequence of events. (1) An instance was presented. (2) The S, who was self-paced, pushed the response button corresponding to his choice of a category. (3) The instance was removed and if S had correctly categorized the instance the green feedback light over the button he pushed came on; if he was incorrect, the red feedback light over the button he pushed came on and the green feedback light over the correct button came on. The feedback lights remained on for four seconds. (4) The next instance appeared.

SUBJECTS

The Ss who participated in the experiment were 36 volunteers, all males, residing in the Regent Apartments of the University of Wisconsin. The mean age of the Ss was 19.4 years. One S failed to understand the instructions and was replaced.

EXPERIMENTAL PROCEDURE

Subjects were scheduled at their convenience and were assigned randomly to treatment groups with the restriction that six Ss were run in each treatment group. On arrival at the laboratory, S sat in front of the response unit and E read the instructions appropriate for the treatment group to which S was assigned. Full sets of instructions can be found in the Appendix. The Ss were instructed as to the type of categorization which they would be required to learn, because the omission of such instructions might have resulted in a continuing search by Ss in the zero relevant dimension condition for some systematic categorization of the instances. Since there was no such system, this search would have been fruitless and might have caused poorer performance not due to the condition per se, but because Ss were looking for a relationship which did not exist.

After the instructions were given, the task began and E recorded each response. A dual criterion for the termination of the task was set; the task ended after S had correctly categorized one block of the 16 instances or after 240 trials. Time to criterion was kept with a stopwatch. Upon finishing, Ss in the R—1 and R—2 treatments were asked if they could label the four response buttons and all Ss were interviewed informally about their reaction to the task.

The order of correct responses was random with the restriction that each of the four response buttons was correct twice in a block of eight trials. Slides of the 16 instances were ordered in blocks of 16. For a given trial, one of four slides could have been presented and paired with the correct response. Which of the four possible slides was in fact paired with the correct response was randomly determined with the restriction that the slide could not again appear until the block of 16 slides was completed. The capacity of the slide magazine was 80 slides, so five different blocks of 16 slides were presented before the first one repeated. It was assumed that the learning of response sequences due to the repetition of blocks could be ignored.

The criterion of 16 correct responses in a block of 16 instances was chosen rather than the more commonly used one of 16 correct responses in a row so that Ss would have to categorize correctly each of the 16 slides. If the criterion of 16 correct responses in a row had been used it was conceivable that S could have achieved this criterion without having responded correctly to all 16 slides.

EXPERIMENTAL DESIGN

The two independent variables were type of classification (2, 1, or 0 relevant dimensions) and type of material (figural or verbal instances). In the R—2 figural condition the dimensions of color and size were relevant to each category so that button 1 represented large-green patterns, button 2 large-red, button 3 small-green, and button 4 small-red. In the R—1 figural condition one dimension, color or size, was relevant for each category so that button 1 represented green, button 2 red, button 3 large, and button 4 small. In the R—0 figural condition no dimensions were relevant to a given category. Thus no value of any dimension was held constant for any of the categories. In the figural condition for R—2, instances appropriate for button 1 varied on number and orientation but all were large and green. In R—1, the instances for button 1 varied on number, orientation, and size but were all green. In R—0, the instances for button 1 varied on number, orientation, size, and color. In the verbal condition, the relevant associational dimensions for R—2 were color and hardness; for R—1, color or hardness; and for R—0 neither color nor hardness were consistently associated with any of the categories.

A 2 x 3 factorial design was used with six replications in each of the six treatment groups. A two-way fixed effects analysis of variance model was assumed with the mean square error term as the denominator in the F ratio both for main effects and for the interaction.

V
RESULTS

It was assumed that the Ss who achieved the criterion of the correct classification of all 16 instances in a block of 16 trials would have performed without error had they continued to the end of the 15 block trials. Consequently, from the trial at which S achieved this criterion, a number of correct responses was added to his score such that this number plus the total number of trials he had undergone to achieve criterion summed to 240 trials. Two hundred forty trials was the alternative criterion, so the adjustment just cited allowed the comparison of scores of Ss which had reached either one criterion or the other.

The results of the analysis of variance on total correct responses will be presented as the initial section of this chapter. Subsequent sections will deal with the analysis of variance on mean time per instance and the results of an informal interview with Ss after the experiment.

ANALYSIS OF VARIANCE ON TOTAL CORRECT RESPONSES

The summary table for the analysis of variance is given in Table 9, and the means for treatment groups are given in Table 10. The F ratios for both of the main effects and for the interaction were significant ($p < .001$). The relationship among the means and the level of attainment of treatment groups are shown in Figure 2. The nature of the interaction becomes obvious from an inspection of this figure.

A trend analysis (Myers, 1966) was included in the analysis of variance in order to describe in detail the curves for the figural and verbal treatments over the three levels of type of classification. The statements derived from this analysis were: (1) The linear trend in the data was significant ($F_{1,30} = 219.35$; $p < .001$) and accounted for 92.1% of the variation due to type of classification; (2) the quadratic trend in the data was also significant ($F_{1,30} = 18.76$; $p < .001$) and accounted for 7.9% of the variation due to type of classification. The significant linear and quadratic components of the interaction showed that both the slopes and shapes of the curves differed significantly.

Because of the significant interaction between the two main effects, a meaningful description of the effects depended upon a subsequent, two-step analysis. First, separate

TABLE 9. Summary Table for Analysis of Variance on Total Number Correct Responses

Source	df	MS	F
A. Type of Material	1	38,155.11	153.75**
B. Type of Classification	2	29,546.25	119.06**
Lin (B)	1	54,435.38	219.35**
Quad (B)	1	4,657.12	18.76**
A x B	2	23,118.39	46.58**
Lin (B) x A	1	15,657.05	63.09**
Quad (B) x A	1	7,461.34	30.06**
Error	30	248.17	
Total	35		

**p < .001

TABLE 10. Mean Number Correct for Treatment Groups

Type of Classification	Type of Material	
	Figural	Verbal
R–0	M = 80.67	M = 176.50
R–1	M = 99.17	M = 205.00
R–2	M = 227.00	M = 220.67

one-way analyses of variance on type of classification for figural and verbal materials were performed. The second step was to use _t_ tests on differences between pairs of means in the event that a one-way analysis resulted in a significant _F_ ratio. In each one-way analysis of variance the mean square error from the two-way analysis was retained for the denominator of the _F_ ratio. This error term was also used as the estimate of error variance in the _t_ tests.

The one-way analysis of varinace on data from the figural condition resulted in a significant _F_ ($F_{2,30}$ = 153.51; p < .001). Subsequent two tailed _t_ tests showed the difference in mean number correct between the R–2 and R–0 groups was statistically significant (t_{30} = 16.09; p < .001). The difference between means of R–2 and R–1 groups was also significant (t_{30} = 14.05; p < .001). The difference between means of the R–1 and R–0 groups was not a significant one.

The one-way analysis of variance for _S_s in the verbal condition also resulted in a statistically significant _F_ ($F_{2,30}$ = 12.12; p < .001). The _t_ tests showed a significant difference between the R–2 and R–0 means (t_{30} = 4.86; p < .001), and between the R–1 and R–0 means (t_{30} = 3.13; p < .05). The difference between means of the R–2 and R–1 groups was not significant.

The learning curves of the six treatment groups shown in Figure 3 also reflect the significant interaction. While _S_s in the figural R–0 treatment were categorizing an average of 6.5 instances correctly in the 15th block of 16 instances, and while _S_s in the R–1 condition were categorizing an average of 9 out of 16 instances correctly in the 15th block, all _S_s in the R–2 group had categorized all 16 instances correctly by the end of the fifth block. The learning curves for _S_s in the verbal treatment groups show a much more consistent increase from R–0 to R–1 to R–2 and look more like typical learning curves.

MEAN TIME PER INSTANCE

Total time to criterion in seconds for each _S_ was divided by the total number of responses made to criterion. The resulting number indicated the mean time in seconds _S_ had spent on each instance. From a two-way analysis of variance on the scores it was determined that _S_s who had observed the figural instances took a significantly longer mean time per instance than _S_s who had observed the verbal instances ($F_{1,30}$ = 11.22; p < .01). Neither Type of

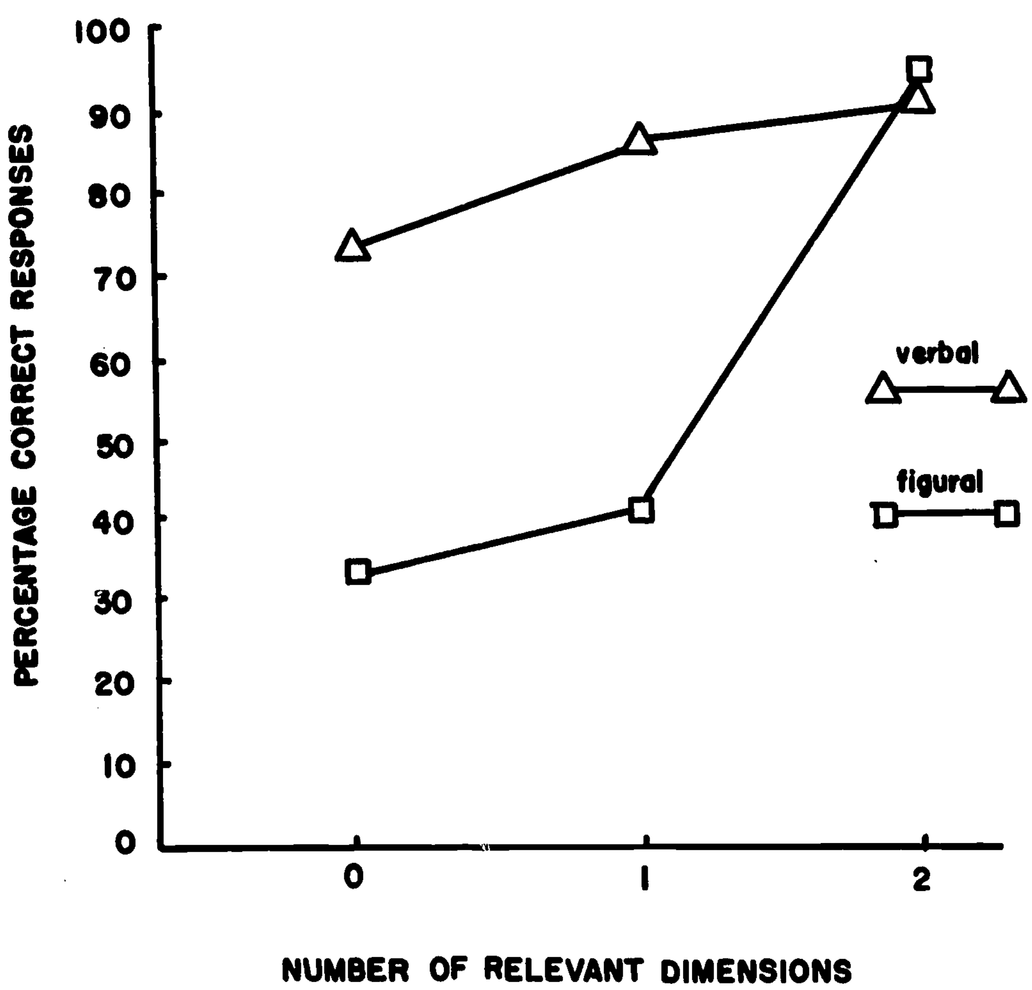


Figure 2. Performance of Treatment Groups as a Function of Type of Material and Type of Classification

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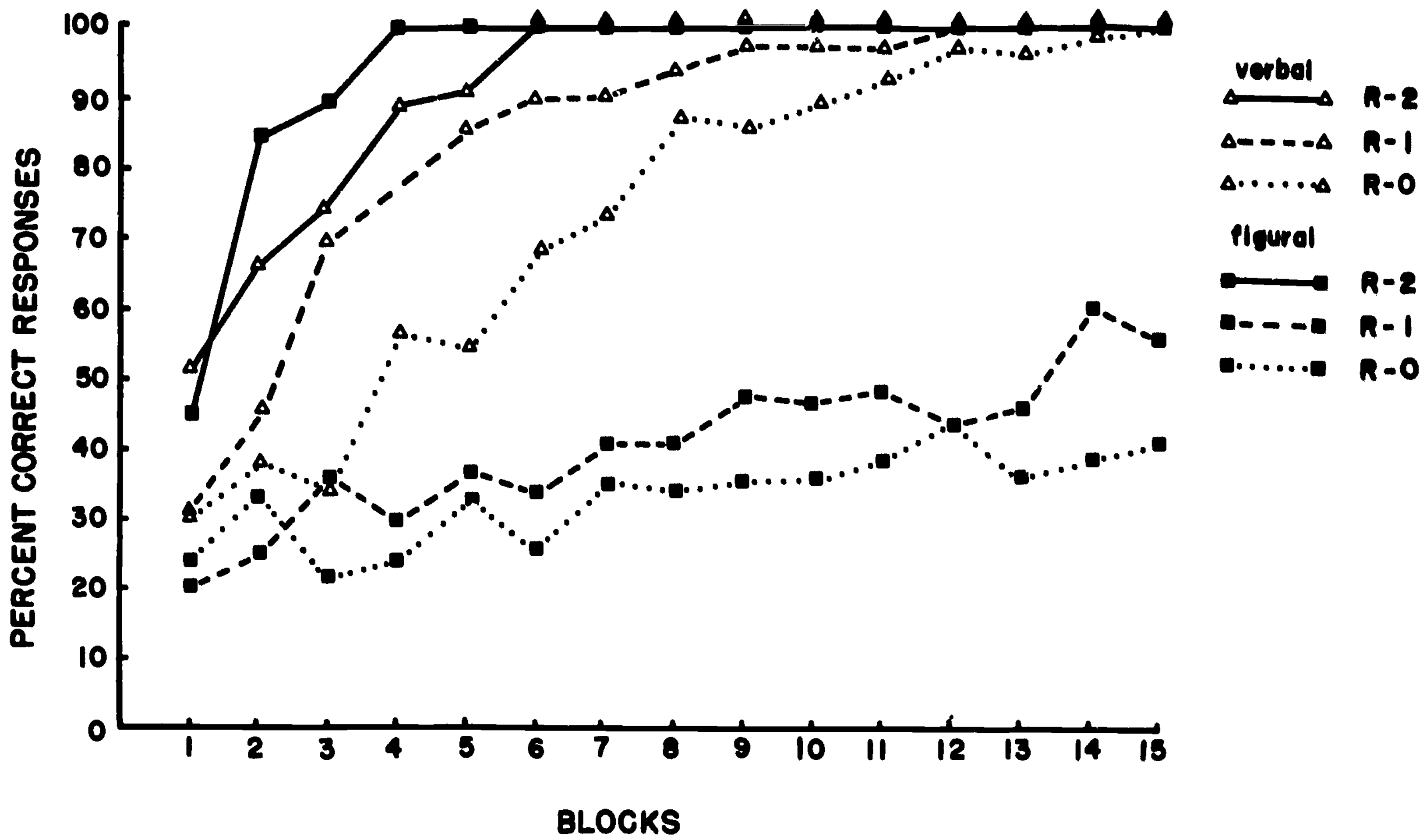

Figure 3. Percentage of Correct Responses as a Function of Treatment Group and Number of Blocks of Trials Completed

Classification nor the interaction of Type of Material and Type of Classification were significant effects. The mean time per instance for Ss in the figural condition was 9.43 seconds; for Ss in the verbal condition, 6.57 seconds. The summary of the analysis of variance is presented in Table 11.

TABLE 11. Summary Table for the Analysis of Variance on Mean Time per Instance

Source of Variance	df	MS	F
A. Type of Material	1	73.59	11.22**
B. Type of Classification	2	10.49	1.60
A x B	2	4.14	< 1
Error	30	6.56	
Total	32		

**p < .01

SUBJECTS' COMMENTS

During the experiment several Ss made spontaneous comments which were recorded by E. After an S had completed the experimental task he was informally interviewed as to what he thought about the task, and any questions he had about the nature of the experiment were answered. The Ss said that once they had begun the task, they found it very interesting and, in some cases, frustrating. One S said after 32 trials, "It made me so angry to see that little red light come on." On the 34th trial this same S said as he observed the instance, "I'm going to make this mistake again," and in making a response did indeed make the same error on that instance that he had made in the previous block of trials.

An S in the R–2 verbal treatment group said aloud in the course of the experiment after incorrectly responding to the instance "rabbit," "Oh, you're using white rabbits." A similar comment was made about the same instance by an S in the R–1 verbal group. Both Ss later said that they would have described rabbits as brown rather than white. These comments indicate that with the verbal material some Ss relied on idiosyncratic associations rather than those which are experimenter-defined.

A clear use of idiosyncratic categorization was illustrated in Ss' responses to the question of what labels they had attached to the four response buttons. This question was asked of those Ss in the R–2 and R–1 conditions. All of the Ss in the R–2 figural group and four out of the six in the R–2 verbal group gave the experimenter-defined labels, the values of the two relevant dimensions, when asked to label the response buttons. The other two Ss in the R–2 verbal group gave "animal" as one of their categories. In the R–1 situation however, only one S in the figural group was able to give the experimenter defined labels. The other Ss in that group said that they had not used labels but had simply tried to memorize which slide went with which button. The most interesting labeling occurred in the R–1 verbal group. Their responses are listed in Table 12. Not one of these Ss completely replicated the experimenter-defined categories, although S No. 28 gave three out of the four labels. All of the Ss identified the instances associated with button 1 as white, but none identified the instances of button 4 as soft. For the latter category, all but one of the Ss indicated that they had used the property of living thing or animal to categorize the instances.

One easily definable strategy for gathering information was used by two of the Ss (S No. 26 in the R–1 verbal group and S No. 3 in the R–0 figural group). In the first block of 16 trials S No. 26 pushed button 1 thirteen times. In the second block he pushed button 1 fifteen times. In these first two blocks he averaged four correct responses. On the third block he made 13 out of 16 correct responses, and reached criterion of 16 out of 16 on the sixth block. This S reported that since he would be guessing the first time through the instances, he had simply pushed button 1 and then had paid attention to the feedback lights which informed him of the correct response.

A variation of this strategy was used by S No. 3. In this case, however, the strategy was not employed until the fifth block of instances. Up to that block there was no systematic pattern of responses and his successes were at chance level. Then on the fifth block he pushed button 1 fifteen times. On the sixth block he pushed button 2 twelve times and also got three out of the four instances associated with button 1 correct. On the seventh block of trials he was able to categorize seven out of the eight instances associated with buttons 1 and 2 correctly. On the eighth block he shifted his attention to button 3. On blocks 5 through 14, or 160 trials, he only pushed button 4 six times. On the 15th block he switched to button 4 and in this final block of trials made 13 out of the 16 correct responses as compared to the 5.4 out of 16 averaged by the rest of the Ss in his treatment group. This S said that he had deliberately set about focusing his attention on each of the buttons in turn.

TABLE 12. Labels given to the Four Categories by Ss in the R–1 Verbal Treatment Group

Experimenter Defined Category	white	brown	hard	soft
Instances	bone skull linen bread	gavel bronze mink chamois	salt enamel chestnut acorn	rabbit sheep cork moccasin
Ss' Code Numbers and Labels				
25	white	brown	miscellaneous	living property
26	white	porosity	-----	brown
27	white	brown	white-hard	brown-animal
28	white	brown	hard	animal
29	white	catch-all	minerals and nuts	animals and leather goods
30	white	brown	element, hard, white, smooth	not brown, animal or animal product

VI
DISCUSSION

Two hypotheses were tested in the study. The first was that the rank order of difficulty in learning to classify instances would be an inverse function of the number of relevant dimensions determining the type of classification, where the number of relevant dimensions was zero, one, or two. Secondly, it was hypothesized that figural material would lead to more difficulty in correct categorization of instances than would verbal material.

While the data generally support the first hypothesis, the exceptions must be noted, viz., that there was no difference between R—0 and R—1 in the figural condition nor between R—1 and R—2 in the verbal condition. A similar statement and qualification can be made with regard to the second hypothesis concerning type of material. While verbal instances were clearly easier to categorize in the R—0 and R—1 conditions, in the R—2 condition, performance was very nearly the same for both types of material. In this last case, the small difference which did occur was opposite to the predicted direction.

From the reports of labeling in the R—1 and R—2 conditions, one possible interpretation of the results can be presented. In the R—1 condition labeling of the buttons might have facilitated performance. In the R—2 condition, the non-experimenter-defined labels used by two of the Ss in the verbal condition might have actually inhibited performance since the animal category used by these Ss was not mutually exclusive of instances in other concepts, whereas the labels for the buttons used by Ss in the figural R—2 condition were mutually exclusive. The suggestion is that labeling is better than no labeling, but mutually exclusive labels are better than labels which allow inclusion of instance from other categories.

The interpretation just posed is one which relates to the construct of mediation. The labels might function as mediators. It was evident that Ss in the verbal R—1 condition had no difficulty in labeling the buttons while Ss in the figural R—1 condition did have difficulty. The use of verbal labels as mediators may have facilitated performance. The mutually exclusive experimenter-defined labels used in the R—2 figural treatment could thus be postulated to be the most efficient mediators.

Another interpretation of the results rests on the assumption of interference occuring as a joint function of type of classification and type of material. According to this interpretation, in the R—0 condition there was interference occurring with both types of material but greater interference with the figural material. This interference was minimized in the R—1 verbal group. At R—2, interference was minimized in the figural group. For this interpretation to be tenable, however, the source of the interference must be specified.

The R—0 condition will be considered first. In this condition where there were no values of dimensions which could be consistently associated with each response button, figural instances were more difficult to categorize correctly than verbal instances. Interference may have been reduced in the latter condition if Ss responded to each instance as a whole rather than as a complex of values on dimensions. For example, learning to push button 1 on the presentation of the instance "salt" may have been easier if salt was remembered as a unitary item rather than as a set of items described as white, hard, grainy, etc. In contrast to this, the figural instances may have been remembered on the basis of their entire set of figural values so that an S needed to remember that button 1 was, for example, the correct response for one large green upright pattern. The finding that longer time per instance was spent on figural material than on the verbal material could be attributed to this analytical vs. holistic perception of the two types of materials. If this difference in the perception of the two types of material occurred, then interference between figural instances may have occurred among any of the values making up the instances while interference between the verbal instances may have occurred on the basis of the unitary item which the verbal instances represented, rather than on the basis of the fractionation of the instances into several associative values.

In the R–1 condition it could be postulated that the same kind of differential perception of the materials occurred resulting in continued interference for the figural group. Assuming that the verbal instances were responded to as single items, the presence of one consistent associative value for each response button would contribute to the similarity of the set of four items associated with each button thus decreasing interference.

In the R–2 condition, the attention given to the specific values of the figural instances could have been highly facilitative to performance since this would be a way to identify just which values were relevant to a particular button and which were not. The perception of the verbal instances as single items in the R–2 condition may have prevented the identification of relevant associative values.

An analysis of the experimental events would also seem to contribute to the understanding of the results. An S had to remember the instance he had just observed in order to associate it with the correct response, since the slides and feedback lights were presented sequentially rather than contiguously. Furthermore, he had only four seconds to concentrate on this association until the next instance appeared. Since one instance only appeared once in a block of 16 instances, an average of 15 instances came between the presentation of an instance and the next presentation of the same instance.

This sequence of events may have contributed to the relatively poor performance in the figural R–0 and R–1 treatment groups. The Ss had to store in memory an instance composed of four values, associate it with one of four response buttons, and remember this association while responding to, and trying to remember the correct response for an average of 15 more four-valued instances. Since five out of six Ss in the figural R–1 group were not able to label any of the buttons, it might be assumed that they were unable to identify the relevant values associated with each button and were therefore faced with the same memory load as Ss in the figural R–0 condition. Assuming that Ss in the verbal treatments stored the nouns as units rather than as a set of discrete values, it would seem likely that they had much less of a memory load imposed on them than Ss in the figural treatments.

It is likely that each of the considerations mentioned above— labeling, mediation, interference, instances stored as units vs. sets of values, time limits in the experimental sequence of events— all contributed to the results of the experiment. This study was not designed to provide evidence as to the efficacy of any of these alternatives, but simply to determine the effects of the independent variables. In this latter respect, the study would seem to have been successful. Some of the differences between treatment group means were so large as to have made statistical tests a validation of the obvious. Now that type of classification and type of material have been shown to be powerful variables, further experimentation can be designed to deal with the alternative explanations of their effects.

For both types of materials, performance was shown to be an increasing function of number of relevant dimensions, but the interaction of type of material with type of classification indicated that the effects of increasing the number of relevant dimensions was not consistent for the two types of material. This inconsistency would suggest that caution be used in generalizing from results of experiments on concept learning based on dimensionalized figural materials to situations where concept learning takes place in a primarily verbal medium.

APPENDIX
INSTRUCTIONS

FIGURAL, TWO RELEVANT DIMENSIONS

What you are about to begin is a learning task. You will be shown a series of 16 patterns like these (show some patterns). After seeing each pattern you will push one of these four buttons. What you are to learn is, which pattern goes with which button. For a given pattern, if the button you push is the correct one, a green light will come on over that button. If your choice is incorrect, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed.

The patterns and buttons have a systematic relationship. This relationship can best be described by using as an example, the sorting of playing cards. A deck of playing cards could be sorted as to suit (clubs, diamonds, hearts, spades), as to color (red or black), as to whether the numbers are even or odd, as to face vs. non-face, etc. Also, the deck could be sorted on the basis of some combination of two of these characteristics. We could sort on the basis of color and face vs. non-face. If we did this we would wind up with four categories of cards: red face cards, black face cards, red non-face cards, and black non-face cards. The 16 patterns you will see have a number of characteristics upon which they could be classified. These characteristics are color (red or green), number (one or two), size (large or small), and orientation (upright or on the side). Each button represents one of the four categories obtained from the combination of two of these characteristics. For example, if the two characteristics were number and color, button one might represent two red, button two - one red, button three - two green, and button four - one green. Using the categories just mentioned a slide showing a pattern with one large green upright figure would be categorized under button four which stood for one green.

To review, your task is to learn which button to push on seeing each of 16 patterns. Each button represents a category and the four categories are obtained from the combination of two characteristics. What you must learn is the category membership of each pattern. On seeing each pattern you will push one of the buttons. If you are correct, a green light will come on over that button. If you are wrong, a red light will come on over the button and a green light will come on over the button you should have pushed. To begin with you will not know what the four categories are which the buttons represent. You will have to guess. The pattern will change only when you have pushed a button, so that you may work at your own pace. I promise you that there is nothing tricky about this task. It is a straightforward learning task. Do you have any questions?

FIGURAL, ONE RELEVANT DIMENSION

What you are about to begin is a learning task. You will be shown a series of 16 patterns like these (show some patterns). After seeing each pattern you will push one of these four buttons. What you are to learn is, which pattern goes with which button. For a given pattern, if the button you push is the correct one, a green light will come on over that button. If your choice is incorrect, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed.

The patterns and buttons have a partially systematic relationship. This relationship can best be described by using as an example the sorting of playing cards. A deck of playing cards could be sorted as to suit (clubs, diamonds, hearts, spades) as to color (red or black), as to odd vs. even, as to face vs. non-face, etc. Also the deck could be sorted on the basis of two of these characteristics. We could sort on the basis of color and face vs. non-face. If we did this, we would wind up with four categories: red cards, black cards, face cards, and non-face cards. As you can see, this kind of classification system is not completely precise. The five of spades fits two categories, black cards and non-face cards. All the other cards also would fit two categories. Once you learned the categories, however, you would have limited your choice to two rather than four categories. You would know for example that the Jack of diamonds would belong to either the category red cards or the category face cards.

The 16 patterns you will see also have a number of characteristics upon which they could be classified. These characteristics are color (red or green), number (one or two), size (large or small), and orientation (upright or on the side). Each button represents one of the four categories obtained from two of these characteristics. For example, if the two characteristics used to classify the cards were number and color, button one might represent two patterns, button two - one pattern, button three - red patterns, and button four - green patterns. As in the playing card example, the basis for classification is not precise. Using the categories just mentioned, a slide showing two green patterns might be categorized under button one which stood for two patterns or under button four which stood for green patterns. What you must learn are the categories and also the specific category for each pattern.

To review, your task is to learn which button to push on seeing each of 16 patterns. Each button represents a category and the four categories are obtained from two characteristics. What you must learn is the category membership of each pattern. On seeing each pattern you will push one of the buttons. If you are correct a green light will come on over that button. If you are wrong, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed. To begin with you will not know what the four categories are which the buttons represent or which pattern goes with each specific category. You will have to guess. The pattern will change only when you have pushed a button, so that you may work at your own pace. I promise you that there is nothing tricky about this task. It is a straight-forward learning task. Do you have any questions?

FIGURAL, ZERO RELEVANT DIMENSIONS

What you are about to begin is a learning task. You will be shown a series of 16 patterns like these (show some patterns). After seeing each pattern you will push one of these four buttons. What you are to learn is, which pattern goes with which button. For a given pattern, if the button you push is the correct one, a green light will come on over that button. If your choice is incorrect, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed.

The patterns you will see have a number of characteristics upon which they vary. These characteristics are color (red or green), number (one or two), size (large or small), and orientation (upright or on the side). There is however, no systematic relationship between the characteristics of the patterns, and the buttons.

To review, your task is to learn which button to push on seeing each of 16 patterns. On seeing each pattern you will push one of the buttons. If you are correct, a green light will come on over that button. If you are wrong, a red light will come on over the button and a green light will come on over the button you should have pushed. To begin with you will not know which pattern goes with which button. You will have to guess. The pattern will change only when you have pushed a button, so you may work at your own pace. I promise you that there is nothing tricky about this task. It is a straight-forward learning task. Do you have any questions?

VERBAL, TWO RELEVANT DIMENSIONS

What you are about to begin is a learning task. You will be shown a series of 16 words like these (show some words). After seeing each word you will push one of the four buttons. What you are to learn is, which word goes with which button. For a given word, if the button you push is the correct one, a green light will come on over that button. If your choice is incorrect, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed.

The words and buttons have a systematic relationship. This relationship can best be described by using as an example, the sorting of playing cards. A deck of playing cards could be sorted as to suit (clubs, diamonds, hearts, spades), as to color (red or black), as to whether the numbers are even or odd, as to face vs. non-face, etc. Also the deck could be sorted on the basis of some combinations of two of these characteristics. We could sort on the basis of color and face vs. non-face. If we did this we would wind up with four categories of cards: red face cards, black face cards, red non-face cards and black non-face cards. The 16 words you will see have a number of associational characteristics upon which they could be classified. Some of these associational characteristics are texture, smooth vs. rough, color, white vs. brown, shape, round vs. flat, and hardness, hard vs. soft. Each button represents one of the four categories obtained from the combination of two of these kinds of associational characteristics. For example, if the characteristics were size and color, button one might represent large brown things, button 2 - small brown things, button 3 - large white things, and button 4 - small white things. Using the categories just mentioned, a slide showing the word "pill" would be categorized under button four which stood for small white things.

To review, your task is to learn which buttons to push on seeing each of 16 words. Each button represents a category based on two characteristics, so what you must learn is the category membership of each word. On seeing each word you will push one of the buttons. If you are correct, a green light will come on over that button. If you are wrong, a red light will come on over the button and a green light will come on over the button you should have pushed. To begin with you will not know what the four categories are which the buttons represent. You will have to guess. The word will change only when you have pushed a button, so that you may work at your own pace. I promise you that there is nothing tricky about this task. It is a straight-forward learning task. Do you have any questions?

VERBAL, ONE RELEVANT DIMENSION

What you are about to begin is a learning task. You will be shown a series of 16 words like these (show some words). After seeing each word you will push one of these four buttons. What you are to learn is, which word goes with which button. For a given word, if the button you push is the correct one, a green light will come on over that button. If your choice is incorrect, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed.

The words and buttons have a partially systematic relationship. This relationship can best be described by using as an example the sorting of playing cards. A deck of playing cards can be sorted as to suit (clubs, diamonds, hearts, spades) as to color (red or black) as to odd vs. even, as to face vs. non-face, etc. Also the deck could be sorted on the basis of two of these characteristics. We could sort on the basis of color and face vs. non-face. If we did this, we would wind up with four categories: red cards, black cards, face cards, and non-face cards. As you can see, this kind of classification system is not completely precise. The five of spades fits two categories, black cards and non-face cards. All the other cards also would fit two categories. Once you learned the categories, however, you would have limited your choice to two rather than to four categories. You would know for example that the jack of diamonds would belong to either the category red cards or to the category face cards.

The 16 words you will see have a number of associational characteristics upon which they could be classified. Some of these associational characteristics are texture (smooth things vs. rough things), color (white things vs. brown things), shape (rough things vs. flat things), and hardness (hard things vs. soft things). Each button represents one of the four categories obtained from two of these kinds of characteristics. For example, if the characteristics were size and color, button one might represent large things, button two - small things, button three - brown things and button four - white things. As in the playing card example, the basis of classification is not precise. Using the categories just mentioned a slide showing the word "pill" might be categorized under button two which stood for small things or under button four which stood for white things. What you must learn are the categories and also the specific category for each word.

To review, your task is to learn which button to push on seeing each of 16 words. Each button represents a category and the four categories are obtained from two associational characteristics. What you must learn is the category membership of each word. On seeing each word you will push one of the buttons. If you are correct, a green light will come on over that button. If you are wrong, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed. To begin with you will not know what the four categories are which the buttons represent, or which word goes with each specific category. You will have to guess. The word will change only when you have pushed a button, so that you may work at your own pace. I promise you that there is nothing tricky about this task. It is a straight-forward learning task. Do you have any questions?

VERBAL, ZERO RELEVANT DIMENSIONS

What you are about to begin is a learning task. You will be shown a series of 16 words like these (show some words). After seeing each word, you will push one of these four buttons. What you are to learn is, which word goes with which button. For a given word, if the button you push is the correct one, a green light will come on over that button. If your choice is incorrect, a red light will come on over the button you pushed and a green light will come on over the button you should have pushed.

The words you will see have a number of associational characteristics upon which they vary. Some of these characteristics are texture (smooth vs. rough), color (white vs. brown), shape (round vs. flat), and hardness (hard vs. soft). There is, however, no systematic relationship between these associational characteristics of the words and the buttons.

To review, your task is to learn which button to push on seeing each of 16 words. On seeing each word you will push one of the buttons. If you are correct, a green light will come on over that button. If you are wrong, a red light will come on over the button and a green light will come on over the button you should have pushed. To begin with you will not know which word goes with which button. You will have to guess. The word will change only when you have pushed a button, so you may work at your own pace. I promise you that there is nothing tricky about this task. It is a straight-forward learning task. Do you have any questions?

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TITLE

Concept learning as a function of the type of material and type of classification

PERSONAL AUTHOR(S)

Ramsay, James G.

INSTITUTION (SOURCE) University of Wisconsin, Madison, Wisconsin
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ABSTRACT

This reports the effects of the number of relevant stimulus dimensions and figural versus verbal stimuli on the concept learning ability of college students. Results force a consideration of mediational variables in explaining this form of cognitive learning.

A set of verbal materials analogous to a set of dimensionalized figural materials was constructed. The figural stimuli were 16 H-patterns, the combinations of values of the four binary dimensions of color (red or green), size (large or small), number (one or two), and orientation (upright or tilted). The verbal stimuli were 16 nouns, four sets of four, which had been shown to be associated with four adjectival categories: hard-white, soft-white, hard-brown, and soft-brown. Two hypotheses were tested: (1) that the difficulty of three classifications would be an inverse function of the number of relevant dimensions composing the classifications, and (2) that figural instances would be more difficult to categorize correctly than verbal instances.

The hypotheses were supported, but needed to be qualified because of significant interaction. Alternative interpretations of results are discussed.