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University of Hawaii, Ph.D., 1976
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THE INFLUENCE OF INSTRUCTIONS ON RELATIONSHIPS
BETWEEN ABILITIES AND PERFORMANCE
IN A CONCEPT IDENTIFICATION TASK

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT
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DOCTOR OF PHILOSOPHY
IN EDUCATIONAL PSYCHOLOGY
AUGUST 1976

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ABSTRACT

Trabasso and Bower's (1968) model of attention and their redundant relevant cues paradigm provided a framework within which the effects of certain instructional treatments were explored. In the redundant relevant cues paradigm, two cues are redundant (i.e., vary together) and either one or both may be used to solve the concept identification task. According to the attentional model, whether a person solves the task on one or both relevant cues is merely a matter of chance. The present study attempted to increase the proportion of subjects solving on two cues by altering certain aspects of the instructions to subjects.

Another major feature of the study was the aptitude-by-treatment interaction methodology. All subjects were administered six factor-analytically-derived ability tests in order to explore the question of whether one- and two-cue solvers differ with respect to ability scores. In addition, the multiple linear regression model was used to test the significance of the difference in relationship of each ability to performance in the task (trials by criterion) among the four instructional treatment groups. The six ability tests were chosen on the assumption that they tapped important processes involved in solving the concept task. Manipulating task variables, such as instructions, implies the possibility of structuring learning
tasks so that the transfer of a subject's unique set of abilities to the task is maximized.

Subjects were 96 students enrolled in the introductory educational psychology course at the University of Hawaii. Each subject was randomly assigned to one of four treatment groups. The four groups resulted from the unique combinations of two levels of each of two treatments, and varied in terms of the initial instructions given to subjects relative to the task. The six ability tests were administered to students in groups during two separate class periods. The ability tests were Memory Span, Spontaneous Flexibility, Verbal, Inductive Reasoning, Flexibility of Closure, and Associative (Rote) Memory.

Many anticipated relationships, effects, and interactions, failed to materialize, probably due to the ease of the redundant relevant cues task. The median number of trials to criterion was 4.7. In an easy task there are fewer processes shared by ability tests and the task and consequently weaker relationships between them may be found.

The proportion of two-cue solvers was not increased significantly by the instructional treatments. Ability test scores were not significantly different for one- and two-cue solvers, though four approached significance. This may have been due to the small number of two-cue solvers (10 out of 96). One- and two-cue solvers were significantly
different with respect to the number of trials to criterion. Though this is not inconsistent with Trabasso and Bower's model, it does appear contrary to their finding of no difference between one- and two-cue solvers with respect to number of errors prior to learning the task.

The single aptitude-by-treatment interaction which reached significance was that involving Spontaneous Flexibility (Fs). The relationship between Fs and trials to criterion was differentially influenced by instructional treatments to a significant degree. Results indicated that for one treatment group Fs, or the ability to break set, was significantly related to learning the concept task.
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I. INTRODUCTION

A Brief History of the Attention Construct

The construct of attention has enjoyed a varied history in psychological theory. The early English empiricists did not invoke the notion of attention. To them, the mind acted mechanically on raw sense perceptions according to the laws of association. Gestalt psychologists also considered attention to be an extraneous construct (Woodworth & Schlosberg, 1954). Functionalists and structuralists, on the other hand, attached great importance to the role of attention, although they were vague about what it was and how it operated (Marx & Hillix, 1963). In 1890 William James devoted an entire chapter on his Principles of Psychology to the subject of attention. He wrote, for example,

My experience is what I agree to attend to. Only those items which I notice shape my mind--without selective interest experience is an utter chaos. (p. 402)

Since the phenomenon had been studied only through introspection, rather than experimentation, it was one of the first mentalistic concepts to be cast aside by the behaviorists. Since about 1950, however, there has been renewed interest in attention among a variety of psychologists. Three major areas of theory and research in attention have
emerged (Trabasso & Bower, 1968). The first is neurophysiological research (see, for example, Hernandez-Peon, Scherrer, & Jouvet, 1956). The focus of this research has been peripheral neural receptors, which can attenuate, or gate out, sensory signals which are of no interest at the moment. Hilgard and Bower (1966) have provided a review of this research. The second major area of research in attention is that of rapid information processing in humans. Dichotic listening experiments have resulted in the development of a very detailed expansion of attention theory. In those experiments, based on early work by Broadbent (1957) and Treisman (1964), among others, the subject usually receives a competing audio signal with each ear. A review of this research is given by Egeth (1966). The third area of attention research and theory is that of discrimination or concept learning. It is this domain within which the present research falls.

**Concept Identification**

The importance of attention in the process of discrimination learning is widely accepted, but little understood. Theories such as that of Trabasso and Bower (1968) attempt to explain the role of selective attention operating as a central mechanism in concept identification. A concept may be said to exist whenever objects or events are classified together and set apart from other objects or events on the
basis of one or more common characteristics (Bourne, 1966). Within the field of human concept learning, the concept identification task has become an important focal point for research. This is primarily due to the fact that concept identification tasks are complex enough to assume that significant cognitive processes are involved and simple enough that behavior in the tasks may be interpreted in terms of precise theoretical models (Atkinson, Bower, & Crothers, 1965).

In a typical concept identification task the experimenter constructs a set of stimulus patterns which can be classified in a number of different ways. It is the subject's task to discover the particular basis on which the experimenter is classifying the stimuli. That is, the subject must identify the concept on which the classification is based.

Given the basic structure of the concept identification task, there are many ways in which the particular experimental application may vary. Chief among them is that either a selection or a reception paradigm may be utilized. Although both paradigms involve the method of anticipation (i.e., the subject makes a response prior to the experimenter's informative feedback), they differ in terms of whether the stimuli are presented simultaneously or successively. In the selection paradigm the entire stimulus population (collection of positive and negative instances of the concept) is available to the subject. Any one of the instances
may be selected, and the experimenter reveals its classification category. This process continues until the subject discovers the basis of classification, the concept which determines the experimenter's feedback. Bruner, Goodnow, and Austin (1956) are primarily responsible for the development of this paradigm. The alternative—the reception paradigm—was first used by Hull in 1920. In this paradigm only one instance is made available to the subject on each trial. The successive presentation of instances substantially increases the memory load for subjects (Cahill & Hovland, 1960). The duration of a single trial is considered to be from the onset of presentation of one instance of the concept to the onset of presentation of the subsequent instance. A trial consists of: (a) presentation of an instance; (b) the subject's classificatory response; (c) informative feedback from the experimenter giving the correct classification for the particular instance; and, (d) intra-trial intervals.

Hull's (1920) original stimulus patterns were modified Chinese characters. Subsequent researchers have commonly used geometric designs because of their familiarity, clear dimensionality, and the ease with which they can be manipulated to suit the requirements of an experiment (Bourne, 1966). In real-world situations the dimensionality of stimuli is often not readily perceivable and the classification rules for concepts may be quite complex. However,
humans are able to abstract, or select, the various properties of stimuli, identify concepts, and generalize, or utilize them for new instances (for further discussion of these phenomena, see the introduction to Bruner, Goodnow, and Austin's *A Study of Thinking*, 1956). This is analogous to the experimental situation, except that the dimensions of the experimental stimuli are simple and familiar. After the appropriate labeling responses come under the control of relevant discriminative stimuli, they are generalized to instances varying in irrelevant attributes throughout the remaining task trials.

On any trial of the receptive concept identification task using the method of anticipation the subject is assumed to sample one or more attribute values of the total stimulus complex in order to generate a response. On the initial trial responses are assumed to be random or influenced only by the learned or innate preferences of the subject. A further assumption is that following an error, the subject samples only those hypotheses which are consistent with information resulting from the error trial. This assumption is referred to as "local consistency" by Gregg and Simon (1967). Thus, as the subject receives informative feedback on each trial, responses become conditioned to dimensions, as well as to values on the dimensions, with a certain probability on each trial, originally designated as $\Theta$ by Estes and Burke (1953).
Stimulus Factors in Concept Identification Experiments

The dimensions or attributes of a stimulus pattern include such aspects as its shape, color, and size. That is, any characteristic which the subject can potentially use to distinguish a positive instance of the concept from a negative instance. In a series of stimulus patterns, a given dimension may assume any one of several values. For example, relative to shape, a stimulus might have one of three values: circle; square; or, triangle. A binary stimulus dimension has only two values (e.g., the color of stimulus patterns may be either red or blue). The number of unique stimuli in a set where each dimension varies independently of the others and every dimension has the same number of values, can be expressed as $V^D$, where $V$ is the number of values on a dimension, and $D$ is the number of dimensions. When all the dimensions are binary, this number is simply $2^D$.

Classification of the stimuli consists of partitioning the total set into two or more categories on the basis of the relevant dimension(s), or cue(s). A dimension (or combination of dimensions) is relevant when the contingency correlation between its values and the correct classifications is unity. Irrelevant dimensions are those which are usually allowed to vary randomly within a category with the restriction that the contingency coefficient is zero. In an example of a two-category concept identification task which
has three binary dimensions, the stimuli might be black or white, circles or squares, large or small. If color is the relevant dimension, and the classification rule is, "Black objects belong to class A and white objects belong to class B," then a stimulus pattern must be labeled "A" if it is black, whether it is a circle or a square, large or small; likewise it must be labeled "B" if it is white, regardless of the value on the other, irrelevant dimensions. A subject may eliminate dimensions from the pool of viable solutions on the basis of information logically conveyed by comparing two instances and their associated categories. When two instances are in the same category, any dimension which has different values must be irrelevant. Likewise, when two instances are in different categories, any dimension which has the same value must be irrelevant.

The Redundant Relevant Cues Paradigm

In a series of receptive two-category concept identification experiments with college students, Trabasso and Bower (1968) utilized the redundant relevant cues paradigm, in which two dimensions were redundant and relevant to the solution of the task and the number of irrelevant dimensions varied from experiment to experiment. There were two values on each dimension. The redundant relevant cues paradigm was thought to be an ideal task for the study of selectivity in learning (Berlyne, 1960).
Trabasso and Bower (1968) used this paradigm to test the utility of their attentional model in relating learning rate to attention values (saliencies) of the relevant cues and in predicting what is learned in the task.

As an example of the redundant relevant cues paradigm, consider a simultaneous discrimination in which shape and color are relevant (perfectly correlated with the correct response category) and number of figures is irrelevant. Red and circle are always paired and the appropriate response is "A"; blue and square are always paired and the appropriate response is "B." The number of figures varies randomly, so that a given number of figures may be part of a stimulus complex which is labeled either A or B. Trabasso and Bower (1968) found that a majority of subjects solved such a task using only one or the other of the two relevant dimensions; however, some subjects learned that two dimensions were redundant and relevant to solution. The fact that some of the subjects were able to solve the task using both cues could not be accounted for by the model which Trabasso and Bower had proposed in 1964. That model, a "one-look" model, assumed that the subject sampled only one dimension per trial. Upon commission of an error, the subject would sample another (locally consistent) single dimension, until a solution was found. Under these assumptions it was impossible for a subject to solve the task on two redundant relevant dimensions. After discovering that subjects did
behave in this way, Trabasso and Bower (1968) rejected their own one-look model and proposed instead a multiple-look attentional model wherein the subject may sample more than one dimension, but a constant number, on each trial. The number of cues used in solving the redundant relevant cues task is referred to as the subject's solution type. Thus a subject may be classified either as a "one-" or "two-cue solver."

**Factors Influencing Solution Type**

Trabasso and Bower (1968) found that the proportion of subjects who noticed that two cues were redundant and relevant, or "two-cue solvers," could be influenced by such factors as the salience of the two redundant dimensions, relative to each other and to the irrelevant dimensions. An increase in the number of irrelevant dimensions, which would be expected to lower the salience of the two redundant relevant cues, resulted in a reduction of the proportion of two-cue solvers. In this study, the dimensions were letters (N, F, J, and Q) and the values on each dimension were upper- and lower-case. An increase in the salience of only one of the redundant relevant dimensions (J or N) by underlining in red one of a cluster of letter "dimensions," for example,
was followed by an increase in the proportion of subjects who solved on that dimension alone. An increase in the salience of both relevant cues within one task (by randomly underlining one or the other relevant letter "dimension," each on half the trials selected at random) resulted in an increased proportion of two-cue solvers.

Trabasso and Bower (1968) also investigated the effect of overtraining on solution type. After a criterion run of 10 correct trials, half the subjects were given 50 overtraining trials before testing. With respect to solution type, Trabasso and Bower obtained different outcomes with different stimulus materials. Overtraining on a task involving letter patterns with two redundant and relevant dimensions and two irrelevant dimensions resulted in no increase in the proportion of two-cue solvers; 17 out of 32 subjects, or 53 percent, solved on both cues with overtraining and the same number were two-cue solvers without overtraining. However, when geometric patterns were used as stimuli, a significant increase in two-cue solvers was observed as a function of post-criterion training. The proportion of two-cue solvers in the group trained only to criterion was 17 percent; in the group having 50 additional trials, 46 percent used both cues in their solutions. The
disparate outcomes of these two overtraining experiments and the results of the other experiments on cue salience mentioned above serve to indicate the important influence of task-situational variables on solution type.

Other factors not investigated by Trabasso and Bower could have contributed to the small proportion of two-cue solvers throughout the series of experiments involving geometric pattern stimuli. Trabasso and Bower (1968) conducted an experiment designed to test the power to predict solution type of their new "multiple-look" model and to test for new learning of a redundant relevant cue after solving a problem in which it had been irrelevant. Subjects were instructed to categorize stimulus cards as either "Alpha" or "Beta." The stimuli consisted of five binary dimensions. Trabasso and Bower's learning model had predicted that 88 percent of the subjects would solve the task on only one of the two redundant relevant cues. This was not significantly different from the 85 percent of the subjects who were in fact found to be one-cue solvers. However, there may have been a tendency for subjects to limit their hypotheses to one-dimensional solutions as a result of a response set induced by instructions. That is, the large proportion of subjects who solved the redundant relevant cues task on only one of the two relevant dimensions may have perceived the isomorphic relationship between number of values on each dimension (two) and number of stimulus categories (two).
In other words, one-cue solvers may have operated under the assumption that the problem's solution would be unidimensional, since each dimension had two values and the problem had two categories. The presumed set to solve the problem unidimensionally may be eliminated, or at least dissipated, by instructing subjects that the stimulus population consists of exemplars and non-exemplars, rather than all exemplars—Alpha or Beta. Trabasso and Bower (1968) suggest that asking subjects to respond "yes" or "no" to the question of whether or not each instance is an exemplar tends to induce a set for asymmetrical partitioning of the population of instances. One of the purposes of the present study was to determine whether this sort of instruction to subjects would increase the proportion of two-cue solvers.

Another feature of the Trabasso and Bower redundant relevant cues procedure (1968) is the method by which subjects were prepared for the concept identification task. All attributes of the stimulus cards were explained in detail to the subject before the task began. The instructions indicated to the subject that each stimulus dimension may have one of two values in a given instance and such instructions may have supported a set to respond to only one dimension of the stimulus complex in seeking a solution to the task. Another way, then, to decrease this presumed response set would be to give no information to the subject
with respect to the number of values per dimension in the stimuli. Under this condition, at the outset of the task, although the subject has been informed of the number of dimensions along which the stimuli may vary, the subject does not know the parameters of the stimulus population. That is, the subject does not know how many values each dimension can assume. A second purpose of this study, then, was to ascertain whether the omission of instructions to the subject regarding the number of values per dimension would increase the proportion of two-cue solvers. Since research indicates (see, for example, Osler & Weiss, 1962) that performance in concept learning tasks improves with specificity of task-related instructions, the less specific instructional conditions in this study should tend to be more difficult than the condition which replicates Trabasso and Bower's (1968) study.

**Individual Differences and Solution Type**

Trabasso and Bower (1968) deal only briefly with the question of whether there are differences between subjects who use one as opposed to both cues to solve the redundant relevant cues task. They suggest that two-cue solvers might, for example, be generally brighter, be less rigid, have better long or short term memory, and/or be faster learners. Further, if the two groups differ in their probabilities of sampling the two relevant cues, the multiple-look attentional
model implies that those subjects with high sampling probabilities tend to learn fast and to learn both cues. The only ability measure available for ex post factor analyses was the subject's error (learning) score. Trabasso and Bower conclude that there was no significant difference in mean number of errors between one- and two-cue solvers and assert that this is the expected outcome according to the model, especially when there are small individual differences in learning parameters (e.g., sampling probabilities or sample size). Moreover it is stated that any ex post facto analysis results could be seen as consistent with the model, given appropriate supplementary assumptions relative to individual differences.

Trabasso and Bower also discuss the possible relationship between individual differences in focus sample size (i.e., the number of dimensions being tested on any given trial) and certain abilities. The focus sample is conceptualized as a list of attribute value and response pairs held in short-term memory from trial to trial (e.g., "blue-Alpha," "red-Beta," "circle-Beta," and "triangle Alpha"). Thus, Trabasso and Bower suggest, the poorer the short-term memory, the smaller the list carried from trial to trial, and the less likely multiple-cue solutions in the redundant relevant cues task. Verbal ability is also discussed in relation to sample size. Since subjects are assumed to encode the stimulus patterns in terms of verbal labels of
the dimensions present, verbal ability may increase the average size of the focus sample which can be remembered from one trial to the next, and consequently affect the solution-type.

It could be assumed that people tend to choose a strategy which is congruent with their individual abilities profile. That is they would tend to adopt a strategy which capitalized upon their particular strengths in terms of abilities.

Presumably, this strategy would involve the attention processes used by subjects in the learning task. To the extent that it can be assumed that different strategies would lead to different solution types (i.e., one- and two-cue solvers) it would be expected that different abilities would be related to performance for the different solution by sex. In order to investigate in greater depth the relationship between individual differences and solution type, it is necessary to measure a greater number of the subject's abilities which are likely to be utilized in the redundant relevant cues task.

**Ability Measures and the Redundant Relevant Cues Task**

Appropriate ability measures are those which may be assumed to tap the abilities utilized in the present redundant relevant cues concept identification task. Ferguson (1954, 1956) has defined ability as performance
which has attained a crude limit and stability across time as a result of learning. The major difference between ability and performance measures according to Ferguson (1954, 1956), is that the former are relatively invariant with respect to learning, while the latter are subject to significant changes as a result of learning over comparatively short periods of time. Abilities are seen as developing through a process of differential transfer of learning, so that abilities and performance are similar in kind but differ in time. Thus learning itself is considered to be a process by which abilities become differentiated, a process which at any stage is facilitated by those abilities already in the individual's repertoire.

The degree to which ability and performance measures in a learning task are related may be seen as depending upon the amount of transfer from previous learning to the task at hand. Several researchers (e.g., Blaine, 1972; Glanzer, 1967; Jenkins, 1967) have suggested that abilities be conceived as process constructs. As the subject learns to solve a given task, he or she passes through states characterized by various processes which intervene between the stimuli and the subject's responses. According to this view, the degree of relationship which exists between an ability test and a learning task depends on the communality of the processes involved. In order to select appropriate
ability measures, a given task must first be analyzed with respect to its hypothesized components.

Trabasso and Bower (1968) assume that performance in a concept identification task consists of alternate modes—a search mode and a test mode. In the search mode the subject selects, or samples, certain attributes of the stimulus array and assigns categorical responses to the values of the chosen attributes. The subject is assumed, in accordance with the assumption of local consistency, to operate in the search mode briefly, following feedback that an error in classification has been made. Each of the attribute-value-response assignments may be seen as a hypothesis regarding the correct rule for classification (the solution). Restle (1962) called this process hypothesis sampling. Trabasso and Bower (1968) refer to the result of the search process, the selected number of attributes with associated categories assigned to their values, as the focus sample.

After selection of a focus sample, the subject is assumed to move into the test mode. The subject tests the currently-held hypotheses by classifying each subsequent stimulus complex according to these hypotheses and evaluating feedback from the experimenter on each trial. When feedback is negative, the sample focus is given up and the subject moves again into the search mode. A solution focus is hypothesized to be one which never reactivates the search process, since it results in errorless performance.
Given the above analysis of the concept identification task, certain ability measures seem relevant to performance in the task. The selection of five measures for the present study was made from a battery recently developed by Hakstian and Cattell (1975) at the Institute for Personality and Ability Testing (IPAT). This Comprehensive Ability Battery (CAB) consists of a total of 20 factor-analytically-derived primary mental ability test. Since an oblique rotation was performed on the factors, the tests are assumed to be correlated to some degree, although reliable estimates of the intercorrelations are not yet available (Hakstian & Cattell, 1975). The Associative (or Rote) Memory (Ma) test was selected because it is a measure of long-term memory, which is probably brought into play in recalling the association between a stimulus attribute value and its category label. Since instructions to subjects were being manipulated as treatment variables in the present study, inclusion of the Verbal (V) test was considered to be important. The ability involved in utilizing the information provided by feedback in order to form and test hypotheses may be tapped by the Inductive Reasoning (I) test, so it was selected. A perceptual ability test, Flexibility of Closure (Cf) involves the ability to focus on key stimulus figures in a perceptual field containing other irrelevant stimuli. This test was chosen because the concept identification task involves the selection of relevant
stimulus dimensions from those which are relevant. Finally, the Spontaneous Flexibility (Fs) test was chosen because it may be tapping a process which is particularly germane to the redundant relevant cues task. Fs is part of an "originality-creativity" cluster of tests, which makes it most interesting in an investigation of the relationship between individual differences and solution type in the redundant relevant cues paradigm. The Fs test taps the ability to break sets and generate a large number of possible groupings of words by a common feature.

A sixth test was taken from another ability test battery, that of French, Ekstrom, and Price (1963). This was a measure of short-term or Memory Span (Ms-1), which is probably the ability involved in recalling the outcomes of recent trials.

Reliability and validity data for the six tests are shown in Table 1.

Relationship Among Abilities, Task, and Treatment

The identification of abilities required by a given task is assumed to relate ability constructs to task variables operationally. Dunham and Bunderson (1969) have indicated that any relationship between abilities and performance in the task could then come under experimental control. Thus, altering task variables should result in altered relationships of abilities to performance on the
Table 1

Reliability and Validity Data for Ability Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Coefficient</th>
<th>Ma</th>
<th>V</th>
<th>I</th>
<th>Cf</th>
<th>Fs</th>
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<tr>
<td>Estimated split-half</td>
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<td>.77</td>
<td>.66</td>
<td>.81</td>
<td>.43</td>
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<tr>
<td>KR-20</td>
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<td>.77</td>
<td>.59</td>
<td>.72</td>
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<tr>
<td>Validity\textsuperscript{a}</td>
<td>.91</td>
<td>.79</td>
<td>.80</td>
<td>.91</td>
<td>.72</td>
<td></td>
</tr>
</tbody>
</table>

Note: The data for these five ability tests were taken from the preliminary results of Hokstian and Cattell (1975). Such data for Ms-1 were not given in the French Ekstrom, and Price (1963) manual.

\textsuperscript{a}This measure is the Pearson product moment coefficient of correlation between the test and the pure factor which it is supposed to measure.

Task. For example, in the Dunham and Bunderson (1969) study, one group was given instructions about how to utilize the available information to solve a concept identification task, and the other group was not. In the former instructional condition, General Reasoning and Induction were found to be related to performance; in the latter condition the important abilities were Associative Memory and Induction. The manipulation of task variables implies the possibility of structuring learning tasks in a way which optimizes the transfer of each subject's unique set of abilities.
In the present study, two instructional task variables were manipulated. The first was the type of stimulus categorization subjects were required to use. In one condition subjects were instructed to categorize all stimuli as either Alpha or Beta, after Trabasso and Bower (1968). In the second condition, subjects were instructed to categorize stimuli merely as exemplars, or non-exemplars of the concept. The second instructional task variable manipulated was completeness of description of the stimulus population. In the complete description condition subjects were instructed as in Trabasso and Bower (1968); that is, all the dimensions of the stimuli and the two values on each dimension were demonstrated to subjects. In the limited description condition subjects were given only instructions regarding the dimensions of stimuli in the task, but were not shown the number of values a stimulus could assume on each dimension. As the two instructional task variables, stimulus categorization and stimulus description, were manipulated, corresponding changes in the relationships between abilities and performance were assessed relative to solution type and learning rate (trials to criterion).

The four central questions explored in this experiment fall into two groups--those involving solution type and those involving the number of trials to criterion. First, do the three new instructional treatment conditions tend to produce a significantly higher frequency of two-cue solvers
than does the instructional condition which replicates Trabasso and Bower's (1968) study? If so, these results would imply that the set for a unidimensional solution might have existed in Trabasso and Bower's (1968) study, but did not exist under the altered instructional conditions of the present study.

Second, do two-cue solvers have different ability score profiles than one-cue solvers? This possibility was acknowledged, but not explored by Trabasso and Bower (1968). If subjects differ in their probabilities of sampling the two relevant cues, then Trabasso and Bower's model predicts that those with high sampling probabilities would tend to take fewer trials to criterion and be two-cue solvers. A higher sampling probability could result from being higher in such abilities as were tested in the present study, according to Trabasso and Bower (1968).

The third question is, how do the four combinations of treatment conditions affect performance (trials to criterion) in the concept identification task? This question has no direct bearing on the Trabasso and Bower model, but studies such as that of Osler and Weiss (1962) have shown that less specific instructions tend to make the task more difficult. Therefore, the difficulty of treatment conditions should be least in the Trabasso and Bower replication cell and increase to the condition in which the conditions were altered in two ways (see Appendix C).
Finally, how do the four combinations of treatment conditions influence the relationship between each set of ability scores and performance in the concept identification task? Conceptually and statistically this is the most important and complex question of the study, since it is really composed of six separate aptitude-by-treatment interaction questions. Different abilities may be found to be important to learning the task under different instructional treatments. Here the Trabasso and Bower (1968) task provides a framework within which to study the interaction of certain abilities and instructional treatments.
II. METHOD

Subjects

Subjects were 96 students enrolled in the introductory educational psychology course at the University of Hawaii. The sample included 30 males and 66 females ranging in age from 20 to 46 with a mean age of 25. Eight ethnic groups were represented, the two largest groups being Japanese (43) and Caucasian (28). The students were recruited in the classroom and received extra course credit for participation in the concept identification task, which was conducted outside class time. (The text of the subject recruitment is contained in Appendix A.) Each of the 96 subjects was randomly assigned to one of four treatment groups. The four groups resulted from the unique combinations of two levels of each of two treatments, and varied in terms of the initial instructions given to subjects relative to the task.

Ability Tests

Five ability tests selected from the CAB (Hakstian and Cattell, 1975) and one test from the French kit (French et al., 1963) were administered by the experimenter to five introductory educational psychology classes from which subjects were recruited for participation in the concept
identification task. The number of students in each class ranged from 20 to 35. Testing was conducted during two separate class periods, the two hand-scored tests (Ms-l and Fs) being administered on one day and the four machine-scored tests (V, I, Cf, and Ma) two days later. The actual testing time for both days was approximately 40 minutes. A complete list of tests with working times is given in Appendix B. Ability test instructions were those supplied by the test manual authors.

The Concept Identification Task

Students who volunteered to take part in the concept identification task were scheduled to do so within four weeks of the time when the ability tests had been administered in their classes. If the subject had not completed the battery of ability tests during class sessions, he or she did so immediately prior to participating in the concept identification task.

The stimuli (see Figure 1) used in the present redundant relevant cues concept identification task were those of Trabasso and Bower (1968). Each stimulus complex contained three irrelevant dimensions: color (red or blue); position of open gap (left or right); and, number of interior lines (one or two). The two redundant relevant dimensions were shape (circle or triangle) and position of dot (above or below the figure). The outlined geometric figures were
Figure 1. The stimuli and associated category labels from Trabasso and Bower (1968).
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Figure 1. The stimuli and associated category labels from Trabasso and Bower (1968).
drawn from the templates onto white 3 x 5 inch (7.62 x 12.70 cm) file cards. The figures were approximately one square inch (645.16 mm$^2$) in area. The dot was .25 inch (1.27 cm) in diameter and was located .25 inch (1.27 cm) above or below the figure.

Each of 96 subjects was randomly assigned to one of the four treatment groups resulting from the 2 x 2 design. The groups differed with respect to the initial instructions which they received regarding the concept identification task. One dimension along which instructions varied was the way in which subjects were asked to categorize the stimuli. Half the subjects were asked to categorize each instance as either "Alpha" or "Beta," while the other half were asked simply to indicate which instances were exemplars of the concept. The other instructional treatment variable was whether or not the subject received the information that the task stimuli consisted of two values per dimension. One half of the subjects were given this information, while the other half were not.

Thus four unique treatment groups resulted. One group received instructions which were essentially those of Trabasso and Bower (1968). That is, subjects were asked to categorize stimuli as either "Alpha" or "Beta" and were given a complete description of the stimuli relative to dimensions and values. A second group was also asked to categorize stimuli as "Alpha" or "Beta," and the task was
explained without reference to the number of values per dimension of the stimuli to be used in the task. A third group was asked to categorize a stimulus as having or not having something which made it an exemplar of the concept. These subjects were told, "Something about some of these cards will make them special. Your job is to decide whether each card is one of these special cards or not."

If the attribute were thought to be present, the subject responded "Yes" to the stimulus, if not, "No." This group was also given a complete description of the stimuli to be used in the task. Members of the fourth group were given instructions to respond "Yes" or "No," depending on whether the stimulus was thought to be an exemplar of the concept or not, and they were given no information about the number of values per dimension in the stimuli. Complete instructions for each group appear in Appendix C.

During the concept identification task the subject and the experimenter sat on opposite sides of a table. A wooden cardholder was placed in the middle of the table. After each subject received appropriate instructions, stimulus cards were presented one at a time on the cardholder. The subjects were given an unlimited response interval, but usually responded within 5 seconds, immediately after which the correct response, printed on a card, was displayed for four seconds beside the stimulus card. The assignment of response categories to the values of the
relevant dimensions was counter-balanced over subjects in each condition. The deck of stimulus cards was shuffled to rerandomize the order before training and after each run through the deck until the subject reached criterion. Subjects learned to a criterion of 32 consecutive correct responses, following the procedure of Trabasso and Bower (1968). Subjects were considered not to have solved if they did not start their criterion runs on or before trial 96 (six complete presentations of the set of stimuli).

**The Sorting Test and Interview**

After subjects had attained the learning criterion, they were asked to sort a deck of 88 cards "according to the rule you have just learned."

The sorting test was modelled after that of Trabasso and Bower (1968) and was used to assess subjects' solution types. The way in which subjects sorted cards indicated (Trabasso and Bower, 1968) whether they had solved the concept identification task using one or both redundant relevant cues. Subjects were required to sort the deck into two categories appropriate to their treatment group. For half the subjects the two categories were "Alpha" and "Beta"; for the other half they were "Yes" and "No," according to whether or not a given card contained an instance of the concept they had learned during the task.
The deck consisted of cards similar to the stimulus cards used in the task. Thirty-two of the cards tested for the learning of the dot cue by "neutralizing" the other relevant dimension of shape. These cards were the same as the concept identification task stimulus cards, except that they were all square in shape. Another 32 cards were used to test for learning of the shape cue. They were like the stimulus cards except that the dot was absent. Sixteen additional cards consisted only of the three dimensions which had been irrelevant during the task: color; number of interior lines; and, location of open gap. The figures were all squares with no dot present and were used to test for guessing on either shape or dot during sorting. A final set of eight cards contained all five of the task stimulus dimensions; however, the dimensions which had been redundant and relevant in the task were put in opposition, presumably creating conflict for a subject who had solved the task on both cues. In these cards, the dot position had been associated with one response category (e.g., "Alpha") while the shape had been associated with the opposite (e.g., "Beta"). These were the last eight cards of the sorting deck and were used to compare the saliences of the two relevant cues, the responses of the two-cue solvers being of the greatest interest. This sorting test was a slight variation on Trabasso and Bower's (1968) method of having subjects sort half the cards described above, but having them sort the deck twice.
After the sorting test, subjects were interviewed briefly and asked to state the classification rule used to solve the task and the rule used to sort the cards; and to describe the way in which they went about solving the task. This last question was asked primarily to investigate the possibility that more than one type of learning strategy may lead to two-cue solving. Having different learning strategies such as those suggested by Brunner et al. (1956) could account for some variance in the relationships between abilities and performance within learning types.
III. RESULTS AND DISCUSSION

Solution Type

In the present study solution type for a subject was determined primarily on the basis of responses to the questionnaire administered subsequent to the concept identification and sorting tasks (see Appendix C). In the two cases in which the verbalized solution was ambiguous, the results of the card sorting test were used to determine solution type.

In their 1968 study Trabasso and Bower based predictions of the proportions of subjects who would fall into three types of solutions (dot, shape, and both dot and shape) on saliences of the two relevant cues and on the focus sample size (i.e., the number of dimensions sampled by a subject on any given trial). The saliences of the dot and shape cues were derived empirically, based on performance of control groups in the study (Trabasso and Bower, 1968) who solved the concept identification task with only one (dot or shape) cue relevant to solution. The salience parameters were estimated to be .16 for the dot cue and .10 for shape, indicating that for this set of stimuli the dot cue was the more salient of the two relevant cues. The focus sample size parameter, which Trabasso and Bower (1968) labeled $s$, was then estimated from the cue saliences along with the
proportions of solution types observed in the study. This was accompanied by utilizing the equations which expressed hypothesized relationships among parameters in the redundant relevant cues paradigm (see Trabasso & Bower, 1968, p. 63).

The cue salience estimates which Trabasso and Bower utilized in their prediction of proportions of the three possible solution types (dot, shape, and both) were found to be inappropriate for the present study, since a greater number of one-cue solvers solved the problem on shape than on dot (see Table 2). Therefore solution type will be discussed only in terms of the number of cues in the solution.

Table 2

Number of Subjects in Each Solution Type by Treatment Group

<table>
<thead>
<tr>
<th>Solution Type</th>
<th>Alpha or Beta Exemplar or non-exemplar</th>
<th>Treatment Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Included</td>
<td>Excluded</td>
<td>Included</td>
</tr>
<tr>
<td>Dot 10</td>
<td>9</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Shape 13</td>
<td>10</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Both 1</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. Number of subjects per treatment group = 24

Out of the total of 96 subjects who solved the task, only 10 (10.4%) indicated that both the dot and shape cues
were relevant to solution. Only 1 subject out of 24 (4.2%) in the cell which replicated Trabasso and Bower's (1968) conditions was a two-cue solver. Trabasso and Bower (1968) predicted 12.2% two-cue solvers in their study and actually observed about 14.6% (13 out of 89 subjects). It was expected that the changes in instructions in the present study would tend to reduce the set for a one-dimensional solution and lead to greater proportions of two-cue solvers. However the results did not confirm these expectations. The overall percentage of two-cue solvers (10.4%) was not significantly different from what Trabasso and Bower (1968) had predicted in their study (12.2%), $z = .55, p = .71$.

The second major question investigated here with respect to solution type was whether or not one- and two-cue solvers tend to differ with respect to ability test scores. Means, standard deviations, and reliability estimates for the six ability tests are contained in Table 3. Table 4 contains Pearson product moment correlations among the tests. Presented in Table 5 are the means and standard deviations of ability test scores and trials to criterion for one- and two-cue solvers. Although the two groups are of quite different sizes ($N_1 = 86$ and $N_2 = 10$), the fact that the variances and shapes of distributions for the two groups were not significantly different allowed a $t$-test to be performed on each pair of ability test means. However, none of these tests produced significant results. Tests
Table 3
Means, Standard Deviations, and Reliability Estimates for Ability Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Number of Items</th>
<th>$\bar{X}$</th>
<th>S.D.</th>
<th>$r_{xx}^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms-1</td>
<td>24</td>
<td>7.98</td>
<td>3.28</td>
<td>.76</td>
</tr>
<tr>
<td>Fs</td>
<td>--$^b$</td>
<td>13.67</td>
<td>3.02</td>
<td>.57</td>
</tr>
<tr>
<td>I</td>
<td>12</td>
<td>8.21</td>
<td>2.23</td>
<td>.67</td>
</tr>
<tr>
<td>Cf</td>
<td>12</td>
<td>8.96</td>
<td>2.83</td>
<td>.83</td>
</tr>
<tr>
<td>Ma</td>
<td>14</td>
<td>9.52</td>
<td>3.25</td>
<td>.78</td>
</tr>
<tr>
<td>V</td>
<td>24</td>
<td>17.46</td>
<td>3.74</td>
<td>.75</td>
</tr>
</tbody>
</table>

Note. Number of subjects = 96.

$^a$All reliability estimates are based on Chronbach's Coefficient Alpha except for that for Fs, which is based on the Spearman-Brown estimate of whole-test reliability from separately timed halves.

$^b$There is no fixed number of items for this test.
Table 4
Intercorrelations Among Ability Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Ms-I</th>
<th>Fs</th>
<th>I</th>
<th>Cf</th>
<th>Ma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fs</td>
<td>.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>.22*</td>
<td>.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cf</td>
<td>.17</td>
<td>.20</td>
<td>.42**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ma</td>
<td>-.02</td>
<td>.08</td>
<td>.21*</td>
<td>.20</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>.44**</td>
<td>.18</td>
<td>.14</td>
<td>.34**</td>
<td>.08</td>
</tr>
</tbody>
</table>

Note. Tabled values are Pearson product moment correlation coefficients, $n = 96$.

* $p < .05$
** $p < .01$
<table>
<thead>
<tr>
<th>Test</th>
<th>of Items</th>
<th>_One-cue^a X</th>
<th>S.D.</th>
<th>_Two-cue^b X</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms-l</td>
<td>24</td>
<td>7.78</td>
<td>2.92</td>
<td>9.70</td>
<td>4.40</td>
</tr>
<tr>
<td>FS</td>
<td>--^c</td>
<td>13.71</td>
<td>3.09</td>
<td>13.30</td>
<td>2.41</td>
</tr>
<tr>
<td>I</td>
<td>12</td>
<td>8.06</td>
<td>2.19</td>
<td>9.50</td>
<td>2.27</td>
</tr>
<tr>
<td>Cf</td>
<td>12</td>
<td>8.84</td>
<td>2.91</td>
<td>10.00</td>
<td>1.76</td>
</tr>
<tr>
<td>Ma</td>
<td>14</td>
<td>9.30</td>
<td>3.15</td>
<td>11.40</td>
<td>3.72</td>
</tr>
<tr>
<td>V</td>
<td>24</td>
<td>17.22</td>
<td>3.73</td>
<td>19.50</td>
<td>3.31</td>
</tr>
<tr>
<td>TTC</td>
<td></td>
<td>11.77</td>
<td>17.49</td>
<td>1.80</td>
<td>3.08</td>
</tr>
</tbody>
</table>

^a_\text{n} = 86. 
^b_\text{n} = 10. 
^c\text{There is no fixed number of items for this test.}
which approached a significant level of difference ($p < .10$) were $I$ (Inductive Reasoning), $Ma$ (Associative Memory), $Ms-1$ (Memory Span), and $V$ (Verbal).

A $t$-test for the difference between mean numbers of trials to criterion for one- and two-cue solves (see Table 5) was performed. Although the results of this test were not significant, the difference in means did approach significance ($p < .10$). This lack of significance was probably due to the highly skewed shape of the distribution of trials to criterion for both groups. Therefore a Mann-Whitney $U$ test, which is not based on the assumption of normal distributions, was performed. The obtained $U$ value was $-74$, which is highly significant ($z = -6.06, p < .0001$). These results suggest that the samples of one- and two-cue solvers were not drawn from the same population.

Pearson product moment correlations between ability test scores and trials to criterion for each of the solution type groups and for the total sample are given in Table 6. None of these correlations reached significance. In addition no difference in correlations for the two groups was found to be significant.

Thus, although it might be expected intuitively that there would be differences between one- and two-cue solvers in terms of abilities or performance, and although several such differences approached statistical significance ($p < .10$), there is no compelling experimental evidence to
Table 6
Correlation of Ability Test Scores with Trials to Criterion by Solution Type

<table>
<thead>
<tr>
<th>Test</th>
<th>One-cue&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Two-cue&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Total&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms-1</td>
<td>.07</td>
<td>.35</td>
<td>.03</td>
</tr>
<tr>
<td>Fs</td>
<td>-.09</td>
<td>-.31</td>
<td>-.08</td>
</tr>
<tr>
<td>I</td>
<td>-.05</td>
<td>.46</td>
<td>-.07</td>
</tr>
<tr>
<td>Cf</td>
<td>.14</td>
<td>-.27</td>
<td>.11</td>
</tr>
<tr>
<td>Ma</td>
<td>-.12</td>
<td>.34</td>
<td>-.14</td>
</tr>
<tr>
<td>V</td>
<td>-.08</td>
<td>.45</td>
<td>-.10</td>
</tr>
</tbody>
</table>

Note. Tabled values are Pearson product moment correlation coefficients.

<sup>a</sup><sub>n = 86.</sub>

<sup>b</sup><sub>n = 10.</sub>

<sup>c</sup><sub>n = 96.</sub>

support these notions. Of course, a larger number of two-cue solvers would provide more reliable estimates of any differences or lack of them.

Trials to Criterion

The concept identification task was relatively easy for these 96 subjects, as indicated by the grand mean of
10.72 trials to criterion. However, the distribution of trials to criterion was highly skewed, with 13 out of 96 subjects making no errors (trials to criterion = 0). The median number of trials to criterion was 4.7. Only one subject failed to solve the concept identification problem by trial 96, probably due to a language difficulty, since she was a foreign student. She was eliminated from the sample.

The mean number of trials to criterion did vary among the four combinations of treatment conditions and in the expected direction. The treatment condition which replicated Trabasso and Bower's (1968) study led to the smallest mean number of trials to criterion (7.67); the condition in which the stimulus categorization was altered and the condition in which the number of values per dimension was not divulged led to almost equally greater mean numbers of trials to criterion (10.42 and 10.21 respectively); and, the condition which included both changes led to the greatest mean number of trials to criterion (14.63). According to Dunnett's test, performed subsequent to a 2 x 2 factorial analysis of variance which produced no significant results (see Table 7), the difference between the first and any other mean did not reach the critical value. Since the lack of significant results may have been due to the skewness of the distributions of trials to criterion for the four groups, a Kruskal-Wallis analysis of variance was
performed. The Kruskal-Wallis test is not based on the assumption of normality of the distributions. However, even this nonparametric test failed to indicate a significant difference among the four groups with respect to trials to criterion, \( H (3) = 4.93, p < .20 \). Thus there was no significant increase in task difficulty due to instructional treatments.

Table 7
Analysis of Variance of Trials to Criterion by Treatment Group

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulus Categorization (A)</td>
<td>1</td>
<td>308.16</td>
<td>1.07</td>
</tr>
<tr>
<td>Stimulus Description (B)</td>
<td>1</td>
<td>273.38</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>A x B</td>
<td>1</td>
<td>16.68</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Subjects</td>
<td>92</td>
<td>286.75</td>
<td></td>
</tr>
</tbody>
</table>

Finally, the question of the effect of instructional treatments on relationships between abilities and learning in the concept identification task was explored. Table 8 contains the Pearson product moment correlations between ability test scores and performance in the concept identification task for each of the four treatment groups, as well as for the total sample. Only one of these correlations was statistically significant, the correlation between scores on the Fs (Spontaneous Flexibility) test and
Table 8
Correlation of Ability Test Scores
with Trials to Criterion by Treatment Group

<table>
<thead>
<tr>
<th>Test</th>
<th>Alpha or Beta Values</th>
<th>Exemplar or non-exemplar Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Included</td>
<td>Excluded</td>
</tr>
<tr>
<td>Ms-l</td>
<td>.18</td>
<td>.11</td>
</tr>
<tr>
<td>Fs</td>
<td>.17</td>
<td>.19</td>
</tr>
<tr>
<td>I</td>
<td>-.02</td>
<td>-.26</td>
</tr>
<tr>
<td>Cf</td>
<td>.01</td>
<td>.01</td>
</tr>
<tr>
<td>Ma</td>
<td>.07</td>
<td>-.32</td>
</tr>
<tr>
<td>V</td>
<td>-.10</td>
<td>-.12</td>
</tr>
</tbody>
</table>

Note. \( n = 24 \) for each group.

\( a_n = .96. \)

*\( p < .01 \)

_trials to criterion for the treatment group which classified stimuli only as exemplars or non-exemplars of the concept and were told the number of values per dimension, \( r = .64, \  p < .01 \). This correlation means that for this treatment group, subjects who scored higher on the Fs test tended to learn the task faster, and vice versa. This relationship appears again in the discussion of the analyses of covariance below._
Means and standard deviations for each of the six ability tests are presented in Table 9; these are given by treatment group as well as for the total group. Any differences among treatment groups on any of the ability tests are assumed to be due to chance, since subjects were randomly assigned to groups; and, in fact, a 2 x 2 factorial analysis of variance performed on each of the six ability measures resulted in no significant F values (p < .05).

Thus, while it has been shown that there were no significant differences in mean ability scores of the instructional treatment groups, the four treatments have differentially affected the relationships between abilities and performance in the concept identification task. Six separate analyses of covariance (using the multiple linear regression model) were performed to explore this question. The covariate was each one of the six ability tests taken in turn; the dependent variable was trials to criterion; and, the four groups were those resulting from the combinations of instructional treatments. The analysis of covariance as it was used in the present study is not of the classical type, since a comparison of adjusted group means was not the purpose of the test. Rather, interest was focused on relationships between abilities and performance in the task, these relationships being expressed as within group regression slopes. The question of similarities and differences in these slopes due to instructional treatments is of
Table 9
Means and Standard Deviations of Ability Test Scores by Treatment Group

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Alpha or Beta</th>
<th>Exemplar or non-exemplar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Values</td>
<td>Included</td>
</tr>
<tr>
<td>Number of Items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ms-1</td>
<td>24</td>
<td>7.92</td>
</tr>
<tr>
<td>Fs</td>
<td>--c</td>
<td>14.00</td>
</tr>
<tr>
<td>I</td>
<td>12</td>
<td>8.25</td>
</tr>
<tr>
<td>Cf</td>
<td>12</td>
<td>8.79</td>
</tr>
<tr>
<td>Ma</td>
<td>14</td>
<td>10.17</td>
</tr>
<tr>
<td>V</td>
<td>24</td>
<td>17.50</td>
</tr>
</tbody>
</table>

\[a \quad \text{n} = 24 \text{ for each group.}\]

\[b \quad \text{n} = 96.\]

\[c \quad \text{There is no fixed number of items for this test.}\]
most importance. Overall and Klett (1972) have suggested that under such circumstances the analysis of covariance might more appropriately be called the analysis of within group regressions.

In any case, the results of these analyses were disappointing. Out of the six abilities tested, only the relationship between Fs (Spontaneous Flexibility) and trials to criterion was differentially influenced by the instructional treatments to a significant degree, \( F(3, 88) = 3.97, \ p < .05 \). Table 10 contains F-ratios for differences in slopes among treatment groups, as well as the \( R^2 \), or

<table>
<thead>
<tr>
<th>Test</th>
<th>F-ratio(^a)</th>
<th>( R^2)(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms-l</td>
<td>&lt; 1.0</td>
<td>.015</td>
</tr>
<tr>
<td>Fs</td>
<td>3.97*</td>
<td>.116</td>
</tr>
<tr>
<td>I</td>
<td>2.00</td>
<td>.062</td>
</tr>
<tr>
<td>Cf</td>
<td>&lt; 1.0</td>
<td>.009</td>
</tr>
<tr>
<td>Ma</td>
<td>&lt; 1.0</td>
<td>.018</td>
</tr>
<tr>
<td>V</td>
<td>&lt; 1.0</td>
<td>.001</td>
</tr>
</tbody>
</table>

Note. \( n = 24 \) for each group.

\(^a\)df = 3, 88

\(^b\)\( R^2 \) = variance in trials to criterion accounted for by the difference among group regression slopes.

*\( p < .05 \)
variance accounted for in trials to criterion by differences among group regression slopes. As was seen in the earlier discussion of r's between ability scores and trials to criterion by treatment group (see Table 8), the behavior of subjects in one group led to a significant difference. This group was the one in which subjects classified stimuli as exemplars or non-exemplars of the concept and were told that there were two values per dimension in the stimuli. For each of the other three treatment groups there was a small, positive relationship between scores on Fs and the number of trials to criterion; however, for the group just described there existed a strong, negative relationship. In other words, only for this group, score on the Fs test was positively related to learning the concept identification task.
IV. SUMMARY AND CONCLUSIONS

Trabasso and Bower's (1968) propaedeutic research and model of attention in human learning, the powerful influence of set on human perception and learning (see, for example, Harlow, 1949), and the body of literature with respect to aptitude-by-treatment interactions (see, for example, Blaine & Dunham, 1972), led to expectations of uncovering many intriguing relationships among abilities, performance in the concept identification task, and instructional treatments of the present study. To a surprising degree these expectations were unfulfilled. Before speculating about causes of the marked lack of significant results, consideration will be given to the single significant relationship which did emerge in this study.

The Fs (Spontaneous Flexibility) test, to reiterate, was developed by Hakstian and Cattell (1975) as part of an "originality-creativity" cluster of tests, and consists of two similar parts, in which a subject must group and regroup seven words on the basis of a different common feature for each group. This test, then, measures the ability to break sets. Scores on Fs were significantly and positively related to learning rate only for the $A_2B_1$ treatment group (see Appendix C). This was the group which was asked to classify stimuli as exemplars or non-exemplars of the concept, and which was told at the outset of the task what
values each dimension could assume. The experimenter asked the A₂B₁ group to respond, "Yes," if the stimulus presented were thought to be one of the "special" cards, and, "No," if it were not. As previously mentioned, Trabasso and Bower (1968) stated that this sort of instruction tends to induce a set for asymmetrical partitioning of the population of instances. Conversely, in the two-category problem, the problem presented in the Alpha-or-Beta categorization condition, subjects tend to expect correctly that half the instances will belong to each category. However, it appears that the A₂B₁ group of subjects began the concept identification task without the aid of a set which would lead to the correct partitioning of instances, since in fact exactly one half the instances were classed as "special cards" (i.e., they were exemplars of the concept). The other instructional treatment for the A₂B₁ group allowed subjects at the outset of the task to be armed with knowledge of all possible combinations of values in the instances except, of course, for the redundancy of the shape and dot cues. Thus it seems that the main obstacle to solution of the task for the A₂B₁ group was an incorrect set with respect to the proportion of stimuli which should be classed as "special cards." Understandably, scores on the test which measured the ability to break sets was positively related to the rate at which these subjects learned the task.
More difficult to explain is the dearth of other significant relationships among the variables of the present study. Manipulation of instructional treatments failed to increase the proportion of subjects who indicated that both the shape and dot dimensions were relevant to solution of the concept identification problem. Trabasso and Bower (1968) found that a series of 50 overtraining trials in which the subject continued to respond correctly, or an increase in the salience of the two relevant dimensions tended to increase the proportion of two-cue solvers. This evidence lends credence to the notion that solution type is a variable which can be influenced by experimental treatment. Therefore it remains to be explained why the particular treatments employed in the present study failed to have any such influence. The treatments were predicated on the assumption that subjects in Trabasso and Bower's (1968) study tended to perceive the isomorphic relationship between the number of categories in the problem (two) and the number of values on each dimension (also two). It was further assumed that this perceived relationship tended to lead to a set for a unidimensional solution of the task. One or both of these assumptions may have been false. Or if these assumptions were true, perhaps other aspects of the task in the present study such as ease of the task and length of the criterion run, outweighed the effect of the initial set for a unidimensional solution.
A further question with respect to solution type is why significant differences in ability test scores failed to materialize. Why do some people indicate that they have noticed two cues are relevant to solution and others indicate only one? Perhaps the task could be solved with such ease (the median number of trials to criterion was 4.7) that solution type for this sample of college students was strictly a matter of chance. Only if the task were moderately difficult would it be possible that individual differences in abilities would be related to task outcomes, because only then would there be sufficient similarity of the processes involved in the task and the ability tests for a significant relationship to exist.

The lack of significant differences may have been due to the selection of inappropriate ability tests. However, although there is no completely accurate method for matching ability tests to task processes, the selection of tests for this study was made judiciously, based on Trabasso and Bower's (1968) analysis of the task and Hakstian and Cattell's (1975) descriptions of the ability tests.

Another possible explanation of the lack of significant differences between one- and two-cue solvers is that the two groups differ with respect to some personality variable rather than any ability. There is informal evidence for this in the discussions carried on with subjects who solved
on two cues, upon completion of the experimental session. When asked how they had come to notice that two cues were relevant to the solution, several subjects reported that they had suspected that the solution they had reached at first (based on one cue) was too simple. Consequently they sampled other dimensions and eventually were continuously reinforced for the second relevant dimension as well as the first. Perhaps the tendency to have such suspicions and/or to look again at the dimensions is related to a personality variable.

Finally there is the possibility that differences between one- and two-cue solvers really do exist with respect to the abilities tested, but that the number of two-cue solvers \( N = 10 \) was too small to lead to reliable results. This possibility is suggested by the fact that differences in four ability tests approached significance \((p < .10)\). The strongest evidence that ability levels are different for one- and two-cue solvers is the finding of a highly significant difference in trials to criterion. This seems contrary to Trabasso and Bower's (1968) finding of no significant difference between one- and two-cue solvers with respect to the number of errors during learning. However, either finding can be accommodated by the model and Trabasso and Bower (1968) state that the only outcome which would be embarrassing to their theory would be to find that one-cue solvers made fewer errors.
Another large set of results which failed to reach expected significance levels were the F-ratios which tested the influence of instructional treatments on relationships between abilities and performance in the task. The exception of a significant F-ratio for the Fs ability test scores has been noted. The fact that the concept identification task was so easy to solve probably accounted for the failure of relationships between abilities and performance in the task to be significantly influenced by instructional treatments. With the median number of trials to criterion being 4.7, there was even little chance of six separate abilities being related to performance in a significant way. In an easy task there are fewer processes shared by ability tests and the task, and consequently weaker relationships between them may be found.

The failure of five out of six aptitude-by-treatment interactions to reach significance is not an uncommon event in the literature. Berliner and Cahen (1973) have suggested that the failure to find significant interactions is often due to improper selection of aptitude (ability) measures or ineffective experimental treatments. However, in the present study it is felt that neither of these flaws existed. The most likely explanation is that, in choosing to replicate the concept identification task of Trabasso and Bower's (1968) study, too simple a task was utilized. Nevertheless, the present failure to demonstrate more than one significant
aptitude-by-treatment interaction should not cast doubt on the important contribution this methodology can make to the field of educational research.

The aptitude-by-treatment methodology allows for studying not only treatment effects, and not only individual differences, but their interaction as well. This point was first made by Lee J. Chronbach in his well-known American Psychological Association presidential address in 1957. Relationships among variables in educational research are seldom simple. Oversimplified conditions in experiments (or studies) at best make the acquisition of knowledge in the discipline slow and at worst distort reality. It behooves the educational researcher to take advantage of the growing number of sophisticated multivariate methods in designing any piece of research. In addition, allowing interactions among variables to take place within the design provides information which cannot be attained through studying variables singly (e.g., a one-way factorial analysis of variance design). In education the aptitude-by-treatment interaction methodology has been employed primarily to investigate how various aptitudes, abilities, or traits, are related to learning certain subject matter under different methods of teaching or differently paced presentation of the material. Berliner and Cahen (1973) have written a review of recent research in this area. The aptitude-by-treatment interaction methodology provides a particularly
hopeful avenue for educational research with respect to the possibility of structuring learning tasks in a way which maximizes transfer of a student's unique set of abilities to the task at hand.
APPENDIX A

SUBJECT RECRUITMENT AND DEBRIEFING

Recruitment

The recruitment below was conducted at the outset of ability testing in five introductory Educational Psychology classes. Ability tests were administered to the groups during two consecutive class meetings, one day apart, and the concept identification task was conducted outside class time on an individual basis within the following five weeks.

My name is Ruth Norton and I am a graduate student in the Department of Educational Psychology. The tests that I will be giving today are part of the research I am doing for my doctoral dissertation.

I know that there is growing resentment among college students with respect to test-taking and so I am going to attempt to convince you that participation in my research is worthwhile. I know that sometimes you take tests in a sort of vacuum, without ever knowing why you took them or what the results were.

So first I would like to tell you something about the area from which my dissertation topic comes. The area is called "Individual Differences." The basic tenet of those interested in this area is that people should not be considered to lie somewhere on a continuum from "bright" to
"dumb"; that is too simplistic. It is more accurate and more useful to look at several separate abilities. As you can probably tell by looking at yourself and your friends, different people have different strengths and weaknesses, different things they are good at doing.

There has been an experimental tradition in psychology such that if, for example, you wanted to find a good way to teach science to fourth-graders, you would teach one group using method A and another group using method B, and then look to see if there were any difference between the two groups in terms of achievement in science. Proponents of individual differences argue that method A may be better for some students and method B may be better for others.

Thus, by giving separate ability tests, like the ones we have here today, schools would be able to match various curricula to students whose strengths lie in a variety of areas.

The topic of my dissertation is specifically concerned with the relationship between how you score on these ability tests, two today and four in the next class period, and how you go about solving a concept identification task, which can be done outside class time. The task is like solving a puzzle. I cannot tell you any more about the concept identification task right now, in order to maintain the validity of the study. However, when the study is all over, I will bring a written explanation of the purpose and design of my study to your class.
I guarantee that the concept identification task will cause you neither physical harm nor embarrassment. It is easy to do and will only take you about 30 minutes. I understand that you will receive extra credit in this class if you choose to participate and I would certainly appreciate your help.

I will pass around a sign-up sheet. If you are interested in participating in this part of the study please write your name and home phone number next to the time which is convenient for you. Your phone number will be used in the event that an emergency arises which causes the experiment to be postponed for that day. Again, this is a very brief experiment and I would certainly appreciate your help.

Please remember that participation in all phases of this study is voluntary. You may leave right now, or drop out at any time.

Of course, I would appreciate it if you would choose to participate. If anyone who takes part in the complete study is interested in seeing his or her scores and having them interpreted, you are welcome to come to my office to do so.

Thank you.

Debriefing

It is important that you do not tell any other students about what we did here today. This is not because the nature of this study is particularly secretive but in order
to make sure the results are not due to people knowing what
to do ahead of time. Your help in this will be appreciated.
If you are interested in the purpose of this study, I will
be coming to your class to explain it later on in the
semester.

Thank you for your participation.
APPENDIX B

WORKING TIMES FOR ABILITY TESTS

<table>
<thead>
<tr>
<th>Ability Test</th>
<th>Time in Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1</strong></td>
<td></td>
</tr>
<tr>
<td>Memory Span (Ms-1)</td>
<td>10</td>
</tr>
<tr>
<td>Spontaneous Flexibility (Ps)</td>
<td>6</td>
</tr>
<tr>
<td><strong>Day 2</strong></td>
<td></td>
</tr>
<tr>
<td>Verbal (V)</td>
<td>6 3/4</td>
</tr>
<tr>
<td>Inductive Reasoning (I)</td>
<td>6</td>
</tr>
<tr>
<td>Flexibility of Closure (Cf)</td>
<td>5</td>
</tr>
<tr>
<td>Associative (Rote) Memory (Ma)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>39 3/4</td>
</tr>
</tbody>
</table>
APPENDIX C

CONCEPT IDENTIFICATION TASK

INSTRUCTIONS TO SUBJECTS

1. Instructions for Group A1B1 (Stimulus categorization--Alpha or Beta; Description of stimuli--Attribute values included)

"The purpose of this experiment is to find out how college students learn to make classifications. I have a deck of cards which may be divided into two classes, called Alpha and Beta. Each card belongs to only one category. Your job is to learn in which category a card belongs. I will show you one card at a time, and you are to classify the card as either an Alpha or a Beta. At first you must guess the category since you do not know the classification. After you classify the card, I will show you the correct answer. Then you will have a few seconds to study the card. I will then show you the next card to be classified. After awhile, you should learn a rule which will enable you to classify every card correctly as either an Alpha or a Beta.

"Before we begin, let me familiarize you with the nature of the cards. Here are two examples of cards which differ in several ways. (Two complementary patterns were shown.) The cards may differ in terms of (1) the shape of
the figure, either a circle or a triangle; (2) the position of the dot, either above or below the figure; (3) the color, either red or blue; (4) the number of lines within the figure, either one or two lines; and, (5) the position of an open gap on the side of the figure, either on the left or right. (These attributes were listed in different random orders for the various subjects.)

"The classification of the card will depend only on what appears on the card and nothing else. The cards are shuffled so that the order of the cards is not important. To review, I will show you one card at a time and you are to classify it as an Alpha or Beta. I will show you the correct classification and then we shall go on to the next card. Guess on the first card. You can learn to classify the cards by a rule. Be accurate and avoid careless mistakes."

After the subject attained the learning criterion, the following instructions were read:

"Okay. You have learned how to classify the cards correctly. Here is a deck of cards similar to the ones you just learned to classify. Would you sort this deck of cards into the categories, putting those cards you think are Alphas under this label and those you think are Betas under this label? I will not tell you whether you are right or wrong during this sort. You sort the cards according to the rule you have just learned."
After the sorting task, the subject was given a printed questionnaire and asked to complete it. The questionnaire consisted of the following:

"(1) Before you were asked to sort the cards, what was the rule you learned which enabled you to classify each card correctly?"

"(2) The rule that I used to sort the cards into Alphas and Betas was ______________.

"(3) Briefly describe the way in which you went about solving this problem. What did you do in order to find out what the rule was?"

2. **Instructions for Group AIB2** (Stimulus categorization--Alpha or Beta; Description of stimuli--Attribute values excluded)

"The purpose of this experiment is to find out how college students learn to make classifications. I have a deck of cards which differ in several ways. The cards may be divided into two classes, called Alpha and Beta. Each card belongs to only one category. Your job is to learn in which category a card belongs. I will show you one card at a time, and you are to classify the card as either an Alpha or a Beta. At first you must guess the category since you do not know the classification. After you classify the card, I will show you the correct answer. Then you will have a few seconds to study the card. I will then show you
the next card to be classified. After awhile, you should learn a rule which will enable you to classify every card correctly as either an Alpha or a Beta.

"Before we begin, let me familiarize you with the nature of the cards. Here is an example of the kind of cards you will see. (One card, drawn randomly from the deck, was shown.) The cards may differ in terms of (1) the shape of the figure; (2) the position of the dot; (3) the color; (4) the number of lines within the figure; and, (5) the position of an open gap on the side of the figure. (These dimensions were listed in different random orders for the various subjects.)

"The classification of the card will depend only on what appears on the card and nothing else. The cards are shuffled so that the order of the cards is not important. To review, I will show you one card at a time and you are to classify it as an Alpha or Beta. I will show you the correct classification and then we shall go on to the next card. Guess on the first card. You can learn to classify the cards by a rule. Be accurate and avoid careless mistakes."

After the subject attained the learning criterion, the following instructions were read:

"Okay. You have learned how to classify the cards correctly. Here is a deck of cards similar to the ones you just learned to classify. Would you sort this deck of cards
into the categories, putting those cards you think are Alphas under this label and those you think are Betas under this label? I will not tell you whether you are right or wrong during this sort. You sort the cards according to the rule you have just learned."

After the sorting task, the subject was given a printed questionnaire and asked to complete it. The questionnaire consisted of the following:

"(1) Before you were asked to sort the cards, what was the rule you learned which enabled you to classify each card correctly?"

"(2) The rule that I used to sort the cards into Alphas and Betas was __________."  

"(3) Briefly describe the way in which you went about solving this problem. What did you do in order to find out what the rule was?"

3. Instructions for Group A2B1 (Stimulus categorization--Exemplar or non-exemplar; Description of stimuli--Attribute values included)

"The purpose of this experiment is to find out how college students learn to make classifications. I have a deck of cards which differ in several ways. Something about some of these cards will make them special. Your job is to decide whether each card is one of these special cards or not. I will show you one card at a time, and you are to say, 'Yes,' if the card is special and 'No,' if it is
not. At first you must guess, since you do not know which cards are special. After you say, 'Yes,' or 'No,' to a card, I will show you the correct answer. Then you will have a few seconds to study the card. I will then show you the next card. After awhile, you should learn a rule which will enable you to decide correctly whether or not each card is one of the special cards.

"Before we begin, let me familiarize you with the nature of the cards. Here are two examples of cards which differ in several ways. (Two complementary patterns were shown.) The cards may differ in terms of (1) the shape of the figure, either a circle or a triangle; (2) the position of the dot, either above or below the figure; (3) the color, either red or blue; (4) the number of lines within the figure, either one or two lines; and (5) the position of an open gap on the side of the figure, either on the left or right. (These attributes were listed in different random orders for the various subjects.)

"The classification of the card will depend only on what appears on the card and nothing else. The cards are shuffled so that the order of the cards is not important. To review, I will show you one card at a time and you are to tell me whether or not it is a special card. I will show you the correct answer and then we shall go on to the next card. Guess on the first card. You can learn a rule which will tell you which cards are special. Be accurate and avoid careless mistakes."
After the subject attained the learning criterion, the following instructions were read:

"Okay. You have learned which cards are special. Here is a deck of cards similar to the ones you just learned about. Would you sort this deck into two categories, putting those cards you think are special under this label ('Yes') and those you think are not under this label ('No')? I will not tell you whether you are right or wrong during this sort. You sort the cards according to the rule you have just learned."

After the sorting task, the subject was given a printed questionnaire and asked to complete it. The questionnaire consisted of the following:

"(1) Before you were asked to sort the cards, what was the rule you learned which enabled you to identify the special cards correctly?"

"(2) The rule that I used to sort the cards into 'Yes' and 'No' was __________."

"(3) Briefly describe the way in which you went about solving this problem. What did you do to find out what the rule was?"

4. Instructions for Group A2B2 (Stimulus categorization--Exemplar or non-exemplar; Description of stimuli--Attribute values excluded)

"The purpose of this experiment is to find out how college students learn to make classifications. I have a
deck of cards which differ in several ways. Something about some of these cards will make them special. Your job is to decide whether each card is one of these special cards or not. I will show you one card at a time, and you are to say, 'Yes,' if the card is special and 'No,' if it is not. At first you must guess, since you do not know which cards are special. After you say, 'Yes,' or 'No,' to a card, I will show you the correct answer. Then you will have a few seconds to study the card. I will then show you the next card. After awhile, you should learn a rule which will enable you to decide correctly whether or not each card is one of the special cards.

Before we begin, let me familiarize you with the nature of the cards. Here is an example of the kind of cards you will see. (One card, drawn randomly from the deck, was shown.) The cards may differ in terms of (1) the shape of the figure; (2) the position of the dot; (3) the color; (4) the number of lines within the figure; and, (5) the position of an open gap on the side of the figure. (These dimensions were listed in different random orders for the various subjects.)

"The classification of the card will depend only on what appears on the card and nothing else. The cards are shuffled so that the order of the cards is not important. To review, I will show you one card at a time and you are to tell me whether or not it is a special card. I will show you
the correct answer and then we shall go on to the next card. Guess on the first card. You can learn a rule which will tell you which cards are special. Be accurate and avoid careless mistakes."

After the subject attained the learning criterion, the following instructions were read:

"Okay. You have learned which cards are special. Here is a deck of cards similar to the ones you just learned about. Would you sort this deck into two categories, putting those cards you think are special under this label ('Yes') and those you think are not under this label ('No')? I will not tell you whether you are right or wrong during this sort. You sort the cards according to the rule you have just learned."

After the sorting task, the subject was given a printed questionnaire and asked to complete it. The questionnaire consisted of the following:

"(1) Before you were asked to sort the cards, what was the rule you learned which enabled you to identify the special cards correctly?"

"(2) The rule that I used to sort the cards into 'Yes' and 'No' was ____________ ."

"(3) Briefly describe the way in which you went about solving this problem. What did you do to find out what the rule was?"
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Dunham, J. L., & Bunderson, C. V. Effect of a decision rule instruction upon the relationship of cognitive abilities to performance in multiple-category concept problems. Journal of Educational Psychology, 1969, 60(2), 121-125.


