# AN EXPERIMENTAL STUDY OF THE EFFECT OF DIFFERENT DEGREES OF "COGNITIVE STRAIN" ON CONCEPT IDENTIFICATION

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Charles Richard Harper

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ABSTRACT

AN EXPERIMENTAL STUDY OF THE EFFECT OF DIFFERENT DEGREES OF "COGNITIVE STRAIN" ON CONCEPT IDENTIFICATION

By Charles Richard Harper

A search for an explanation of variations in effectiveness of presentation sequences used as guidance in the concept identification task initiated the present investigation.

The amount of "cognitive strain" induced by the sequences was postulated from past research as a possible explanatory principle. "Cognitive strain" was defined as stress on the cognitive schema and it was hypothesized that an inverse relationship exists between "cognitive strain" and concept identification. The effect of levels of intelligence was also tested to determine their relationship to correct concept identification.

Subjects were students of three classes of Introductory Psychology who were asked to write a rule identifying the intended concept after viewing a sequence of slides containing geometric figures, which were projected on a viewing screen. The rule was explained as the values of two dimensions that occurred more than once in a particular sequence. The geometric figures varied in four dimensions and on four values in each dimension.

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Degrees of "strain" were created by manipulating (a) total amount of information presented, (b) amount of interposing information and (c) amount of information stored during a problem in a series of slides.

Each subject responded under all five degrees of "cognitive strain". Identifications were scored for the number correctly made by each subject.

An analysis of variance of the main effects of group membership, intelligence levels, and presentation sequences was made with repeated measurements on the sequences. The results showed a decreasing number of concepts correctly identified in each sequence when the latter were ordered for increasing "cognitive strain". Differences were statistically significant for the comparison of adjacent sequences in three of the possible four comparisons.

The data supported the hypothesis of an inverse relationship existing between amount of "cognitive strain" and effectiveness in concept identification.

The hypothesis that a positive relationship between intelligence and concept identification would be found also appeared statistically warranted. No significant interactions between the main effects were discerned.

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Charles Richard Harper

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# CHAPTER I

## INTRODUCTION

In order to identify a concept a person must abstract or infer from the sensory data available to him and from his past experiences. He must focus on common features of repeated stimuli and recognize them as essential instances of the concept to be identified. The process of abstraction or inference in concept identification is, thus, basically that of distinguishing the relevant information in stimulus situations.

However, some irrelevant information is always present and must be handled by the learner. Although irrelevant information does not directly identify a concept, irrelevant information can be information-giving in terms of defining what a concept is not. The amount of information, both relevant and irrelevant, and the sequence in which information is presented can be manipulated by a teacher. Teaching, therefore, in this context can be considered as the use of procedures intended to facilitate the complex sorting task the learner faces and the general question arises - "What conditions determine the effectiveness of a presentation sequence in the guidance of concept identification?"

## The Problem

A specific answer to the general question was evolved from the conclusions written by Bruner, Goodnow and Austin (2). In their investigations, they were concerned with the strategies problem solvers use in attaining concepts and suggested that different types of instances and orders of presenting instances will either increase or decrease "cognitive strain". (*) The latter term was not given an operational definition by these authors. The term "cognitive strain" (**) denoted a hypothetical construct and was used in the present study to suggest an inferred intermediate mechanism and is defined as "stress on the cognitive schema resulting from a noticeable increase in cognitive activity as a subject attempts to attain a concept." In the present study, anchor points by which the amount of "cognitive strain" can be ordered will be presented and it will be hypothesized that the effectiveness of various presentation methods used in the guidance of concept identification is explained by the degree of "cognitive strain" each of these methods entails.

The value of understanding the relationship between "cognitive strain" and concept identification lies in its being a more direct

(*) "Cognitive strain" will always appear in the text in quotations to signify that this is a hypothetical construct.

(**) Cattell has defined a "law of cognitive-dynamic investment strain. Increase in the number of intermediate cues and subgoals in reaching a goal, as well as increase in the fineness of cognitive discriminations to be maintained, and increase of the length of time that intermediate, anticipatory mental sets (deferred action to cues) have to be maintained, occasion a strain of total cognitive-dynamic energy." (3) Cattell's definition was formulated to apply to a different context, that of personality theory.

basis for determining the effectiveness of concept identification as compared to analyzing the characteristics of a stimulus. The characteristics of a stimulus only influence cognitive activity and thereby indirectly vary the effectiveness of concept identification.

Limitations of the Present Study

Investigation of the process of identification of elements common to a class of objects may be unreliable because of the difficulty of controlling the subjects' past experience. However, the categorizations employed in identification of concepts may be considered as occurring at a perceptual level and a conceptual level. The principal difference between the two levels is in the immediacy to experience of determining fitness of attributes to categories (2). It is possible to study categorization at the perceptual level and reliably evaluate the process by using tasks sure to be familiar to all subjects.

By evaluating the process at the perceptual level, it was assumed that inferences about the processes of concept identification at the conceptual level could also be made. The observations made in this present study were at the perceptual level and used a concept identification task with familiar, readily distinguishable features.

The tasks used in the present investigation were all instances of a conjunctive concept, a type of concept in which all objects of a class — in this case "correct" identifications — share common characteristics. Instances of the concept were varied on four dimensions and on four values of each dimension. Dimensions are the attributes of

features of an event that is susceptible to some discriminable variation. The variations of the dimensions are called values. In each of the problems used there were two relevant dimension values to be identified. Relevant dimension values are the values of the dimensions that define a concept in a particular instance as compared to the irrelevant values which are contained in an instance but which do not identify a correct concept.

The experimenter selected the order of the instances and the rate at which the instances were presented, as well as the length of time they were exposed. The subjects were instructed as part of the directions that each instance to be presented would contain one or two relevant dimension values. No information on the "correctness" of identification was provided by the experimenter.

These special characteristics of the tasks used to explore the relationship of "cognitive strain" to the effectiveness of concept identification all limit the inferences that can be made of the experiment to be reported in the chapters that follow.

## CHAPTER II

## RELATED RESEARCH

The basic purpose which motivated this investigation was to discover "what conditions determine the effectiveness of a presentation sequence in the guidance of concept identification?" Early attempts by educational psychologists to attack this problem are exemplified by the work of Pechstein (13) and Hanawalt (7). They, and others, investigated the presentation problem in terms of "wholes" and "parts" but their evidence gave quite contradictory results. The contradictory results may have arisen because of the failure of the early experimenters to arrive at a definition of "wholes" and "parts" which could be applied over a wide range of tasks. Or the failure to obtain consistent findings may have been caused by the experimenters' exclusive concentration of the stimulus to the exclusion of any consideration of hypothetical cognitive processes. But whatever the correct explanation, the "whole-part" approach to explaining the effectiveness of various presentation sequences became stagnated. In Underwood's opinion "the reason for this is probably that no comprehensive hypothesis concerning the variable has been set up by which the success of the studies may be evaluated." (17)

<u>The General Problem of Concept Identification</u>

In the early 1930's, K. L. Smoke (14) conducted a series of experiments in which concepts based on geometrical designs were to be given names. An example would be a triangle with a line at right angles extending from the shortest side which was to be identified as a "mib". Triangles with lines extending from other sides were not "mibs". Smoke felt that the chief advantage in the use of non-representational diagrams in investigating concept identification was that it avoided the influence of previous learning that would be confounding if more meaningful concept problems were used. Later studies, including the present one, have followed Smoke in this practice.

In Smoke's investigation, examples of the concept to be identified were referred to as "positive or negative instances". A positive instance was defined as a stimulus complex which contained all of the relevant characteristics of the concept of which it was an example. A negative instance was a stimulus complex which did not present any or all of the essential elements of a given concept. Each presentation contained a positive or negative sign to inform the subject of the kind of information that instance contained.

From the results of his experiments, Smoke concluded that there was no significant statistical evidence on which to conclude that concept identification proceeds either more or less rapidly when the series of examples used to develop a concept contained both positive and negative instances than when it contained only positive instances. The criterion of effective learning was amount of time used to identify a concept.

Smoke's conclusion was the basis for many later studies on the relative effectiveness of the presentation of positive and negative instances. Of these studies, a report by Hovland and Weiss (9) is of special relevance to the present investigation. These experimenters used Weigl-type cards and flowered designs varying in form, color, quantity and size which were displayed by 3" x 5" cards on a table for five seconds with twenty seconds allowed for the subjects to identify the concepts. Hovland and Weiss presented evidence that the exclusive use of positive instances was superior to the presentation of only negative instances and that a combination of positive and negative instances in a learning series was intermediate in effectiveness. In discussing their findings, the authors pointed out that a major research task remained — that of determining the conditions responsible for the greater effectiveness of positive instances. In an earlier investigation, Hovland (8) alone had suggested that "separate analyses must be made of . . . the process of assimilating information from the two types of instances when the amount of information transmitted is equated".

Hovland and Weiss's conclusions substantiate the need for an answer to the basic question of this investigation - "What conditions determine the effectiveness of presentation sequences in the guidance

of concept identification?" However, it was the interpretation of the conclusions of Bruner, Goodnow and Austin (2) which led the investigator away from further consideration of positive and negative instances to postulating that "cognitive strain" might offer an explanation. Bruner and his co-workers were interested in what went on within their subjects. In their investigations, subjects were shown cards which contained figures varying in color, shape, number of figures and type of border. In each problem the one "correct" concept was to be discovered by the subject from a series of cards displayed to him.

Two general methods or strategies were described as characterizing the process by which subjects arrived at the "correct " concept. In one, the "focusing" or "wholist" strategy, the initial card as a whole was made the basis of a trial hypothesis by the learner. The subject's response made it appear, or the subject said, that he compared the subsequent card with his memory of the original one, looking for the features the latter had in common with the first and ignoring other features. In the second, "scanning" or "partist" strategy, the subject would "bet" on one aspect of the original card, such as its color, as being the basis of similarity and key to the concept. He then had to change his hypothesis whenever he met a contradictory instance and had to remember other features of the first card so as to form a new hypothesis. The subjects who adopted the focusing strategy did better on the whole than did the scanners, although they were equally affected by increased difficulty of the problem.

Bruner and his co-workers concluded that the "scanning" placed a greater demand on the subject's memory and used the term "cognitive strain" to describe the increased dependency on memory. It should be emphasized that it was the strategies used by problem solvers that were the main concern of the investigators and not the method of presenting information. The important contribution of their analysis to the present study is the idea of "cognitive strain" though this term was not defined nor was its relationship to concept identification directly specified.

Bruner, Goodnow and Austin, then, stated that increasing the demand on the subject's memory produced increased amounts of "cognitive strain". In examining the characteristics of concept identification tasks which could be manipulated by the teacher — or the experimenter — and which could be presumed to place some additional burden on the subject's memory, the writer was led to consider three conditions that might more objectively increase "cognitive strain". These conditions are: (a) the amount of information presented to the subject, (b) the amount of interposing information, and (c) the amount of information that must be stored during the course of a problem.

Thus, one study has drawn conclusions concerning the effect of an increase in the total amount of information presented for observation by increasing the amount of irrelevant information. Archer, Bourne and Brown (1) had subjects, seated before an oscilloscope screen, observe a series of moving geometrical forms. The figures could be circles or

ellipses, large or small, bright or dim, steady or irregular in contour and they could be traveling rapidly or slowly across the face of the tube and in one direction or the other. Only four categories were selected as relevant at any one time — all others were irrelevant to the concepts to be identified — and the subject had four buttons before him. The subject attempted, by a combination of trial and error and reasoning, to discover a correct concept. The results showed that difficulty was augmented, with increases in irrelevant information, whether measured by time to reach the criterion of thirty-two successive correct responses or by the number of errors made.

Another series of studies may be cited here to illustrate the effects on concept identification of interposing information. Hunt (10) designed an experiment to get data on the form of the "information retention curve" as a function of the serial position of the information which was to be retained. The stimuli were geometric designs with dimensions and values of: type of figure (star, fleur-de-lis, "X", and cross), shape of border (circle or square), color of figure (outline or filled in) and orientation of the "side panels" (0 - 180°, 45 - 225°, 90 - 270°, 135 - 315°). The side panels were rectangles extending out from the border of the design. The designs were dittoed and stapled into a book. Instances were presented by having subjects turn the pages of their books on a signal from the experimenter. In a second experiment, the number of interposing instances was increased. In a third experiment, the three key instances, which transmitted information over different dimensions, were presented at various positions in a

constant length training series. The three experiments together presented a consistent picture of interposing information effects during concept learning. Hunt concluded that as the number of instances interposing between the original presentation and the test series were increased, the number of errors in identification of concepts was increased.

Finally, in an extensive series of experiments designed to explore the factors that control the efficiency of performance on the type of concept problems introduced by Smoke and later studied by Hovland, Glanzer (5) has advanced experimental definitions of the systematic operations carried out by subjects. Conjunctive concept tasks were used with two categories, multi-dimensional, multiple-problem series and a specification of the number of relevant dimensions.

In the first four of the series of six experiments Glanzer reported, the systematic operations of the subjects were viewed as consisting of the storage of dimension values and the selection of dimensions. To demonstrate the effects of "storage load" and "selection load", an index for both was developed using perceptual data Glanzer had recorded in a separate experiment in 1961. Glanzer measured perceptual difficulty and assumed that values which were difficult to perceive under short exposure would be difficult to store under ample time exposure. The indices were used to construct eighty conjunctive concept problems equally divided in the following four categories according to the load imposed on storage and selection: low storage load, low selection load; low storage load, high selection load; high storage load, low selection load; high storage load, high selection load. The results showed that increases of load on either the storage function or the selection function decreases the efficiency of concept work. No interaction appeared between the two factors. Storage load was found to have a considerably greater effect than that of the selection load.

Of most significance to the present study was the development of indices of storage and selection loads whereby the investigator had measured "cognitive strain", and his suggestion that an experimenter can obtain load estimates that will give a basis for manipulating load on the basis of assumptions about the subject's encoding. In the present experiment, it is the quantity of information that a subject must encode that is the assumed basis for varying "cognitive strain".

Summary of Related Research

A type of concept identification problem was introduced by Smoke (14) and studied by Hovland (8,9) that classified examples as either positive or negative instances. The effect of using positive or negative instances in presenting concepts to subjects was evaluated but the reason for the superior effectiveness of positive instances was not determined.

In attempting to study the strategies used by problem solvers,

Bruner, Goodnow and Austin advanced the idea of "cognitive strain" and this appeared to hold promise for explaining the earlier findings. The literature on the concept identification problem suggested that three conditions, each of which had been studied in isolation, might provide the basis of a more operational definition of "cognitive strain". These conditions were: (a) the amount of information presented, (b) the amount of interposing information, and (c) the amount of information to be stored during the solution of a concept identification task.

# CHAPTER III

## HYPOTHESES AND RATIONALE

On the basis of a review of the literature, it can be argued that methods of presentation designed to cause different degrees of "cognitive strain" will, in turn, result in different degrees of effectiveness in solving concept identification tasks. In effect, this way of putting the proposition related the effectiveness of guidance in concept identification to activities assumed to occur within the subject and is, in this sense, a phenomenological explanation. Its advantage is that it offers a more direct basis for understanding the effectiveness of alternative presentations than the analysis of only the stimulus characteristics of the presentations, since these characteristics only create conditions which affect the cognitive activity of the subject.

Certain assumptions must be made in advancing a hypothesis based on this argument. They include a belief that all information given to a subject in the course of a concept identification problem will be considered relevant by him and that he will attempt to retain all such information until its relevance is confirmed or disconfirmed. Until some basis for discarding information is given to him, a subject cannot know what information is relevant or irrelevant and must treat all information observed in connection with a task as necessary to

its solution. Any increase in the amount of information to be observed and retained by the learner, and any delay by interposing instances in the presentation of confirming instances may be expected to increase the cognitive activity.

A noticeable increase in the cognitive activity required in a problem will produce "cognitive strain" for the cognitive activity will approach the cognitive capacity of the individual. Under the conditions of "strain", the individual will not function effectively. In a task of identifying concepts, as the individual's capacity is approached, the individual under "strain" no longer has sufficient cognitive energy available to attend to additional information which is available and actually relevant to solving a problem. Without cognitive energy available, the assimilation of information which is actually relevant to a decision does not occur, and does not enter the learner's cognitive realm for use to make a correct concept identification. In addition, as the individual under the "strain" to make a decision acts, he makes a decision using information which is actually irrelevant but which he already has within his cognitive realm. A decision using actual irrelevant information is incorrect. As the "cognitive strain" increases, the amount of incorrect decisions increases, resulting in an inverse relationship between "cognitive strain" and concept identification.

The amount of "cognitive strain" in a given concept identification task will be affected by the capacity of the individual.

An indirect measurement of cognitive capacity can be approached through the use of a standardized test of mental ability since such tests are developed to evaluate the ability of individuals to deal with concepts and symbols (16). In any given experiment in concept identification, the expectation would be that persons scoring high on such tests would be more successful than those of lesser ability. Unless such a relationship were obtained, one would have to question the validity of the tasks used -- or of the mental ability test.

While "cognitive strain" occurs within the individual and cannot be directly observed, the manipulation of presentations will effect "cognitive strain" as demonstrated by Glanzer (5). There are three conditions which may be manipulated to create different types of sequences of presentations and which will increase "cognitive strain".

First, as the total amount of information that is presented is increased, the learner will attempt to use all the information to the effect that there will be a noticeable increase in cognitive activity which results in "cognitive strain".

Second, an increase in the amount of information observed between the original observation of a stimulus complex and the use of the stimulus complex causes a noticeable increase in cognitive activity to handle the interposing information with the result that "cognitive strain" is increased.

Finally, an increase in the amount of information stored during a problem may cause a noticeable increase in the cognitive activity, resulting in "cognitive strain".

These considerations suggested the following hypotheses which became the basis of the experiment to be described:

Hypothesis I - There will be an inverse relationship between the number of concepts correctly identified and the amount of "cognitive strain" induced by increasing the amount of (a) information presented, (b) interposing information and (c) information stored during a problem.

Hypothesis II - There will be a positive relationship between cognitive capacity, as indirectly measured by the Otis Quick Scoring Mental Ability Tests, and the number of concepts correctly identified.

Several procedures were used to randomize and counter-balance extraneous variables which are described in the two chapters that follow. The control procedures will prevent interaction effects from being significant.

## CHAPTER IV

## THE EXPERIMENT

Verification of the hypotheses was undertaken by conducting an experiment in which subjects were given the task of identifying concepts involving geometric figures presented in a series of projected slides. Subjects were told that the experiment was a task in remembering and that they would observe either two, three or four slides. The figures to be used were demonstrated and described as varying on four dimensions and that on each dimension four values were to be used as follows:

| Dimensions | Values |
|---|---|
| Form | Circle, triangle, cross, square |
| Color | Orange, green, black, red |
| Size | Large, medium, small, tiny |
| Quantity | One, two, three, four |

The attention of the subjects was directed to two pairs of horizontal lines appearing on the viewing screen. Instruction included the information that the narrow horizontal lines on the screen were the height of the "small" shapes. Shapes that were not as tall as the narrow lines were "tiny". The wide horizontal lines were the height of "medium" shapes. Figures which were larger than the wide lines were "large".

Preliminary testing with figures differing in three values of shapes, number and color resulted in a uniformly high amount of correct concepts identified. To increase variation in the number of concepts identified, the number of values was increased from three to four and a fourth dimension was added. The addition of a border dimension was tried. During trials with a border, it was discovered that this dimension required the shift of attention as in attending to a second separate figure, unnecessarily confounding the problem. In order to eliminate the need of a shift of attention, size, which is an integral part of the stimulus figure, was substituted for border as the fourth dimension.

Preliminary trials also disclosed that the instructions were ineffective in getting subjects to record the specific value of a dimension instead of just the dimension to identify the concept. To eliminate the lack of response specificity, one example of each type of sequence was displayed during the instructions to the subjects and a sample response sheet was projected so that the correct method of recording dimension values could be demonstrated.

After viewing a slide sequence, subjects were asked to write a "rule" identifying the concept. It was explained that the "rule" should identify the two dimension values that occurred more than once in a series. Subjects were instructed not to make notes and color blind individuals were identified so that their responses could be eliminated from the evaluation of the experiment.

Development of Five Sequences

The three conditions that were hypothesized to cause "cognitive strain" were applied to the arrangement of examples in a series. Five different types of arrangements of examples were developed and each was labeled as a type of "sequence". The five different types of sequences created five different degrees of "cognitive strain".

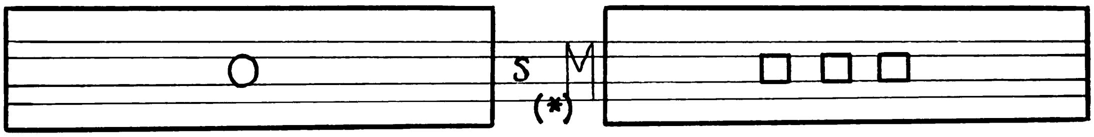
The construction of the five types of sequences was based on the assumption that a subject will attempt to use all information available to identify a concept, that he will not make errors in perception, that once a correct identification is made it will be maintained, and that deviations from the ideal use of information will be no greater for one type of sequence than for any other type of sequence. The amount of relevant information in all types of sequences was equal.

Sequence I - Least "Cognitive Strain" - To provide the least amount of "strain", a series of slides was prepared, each of which consisted of two slides. Both values of the concept to be identified were presented on each of the two slides.

Example of Sequence I

First Slide

Second Slide




Open Figures Denote Red

Concept: Red - small

The total amount of information (in the example, the six values - red, small, one, circle, three, square) was at a minimum. There were no interposing slides between the original exposure of the concept and its confirmation. Thus interposing information was at a minimum. The amount of information that must be stored during the solution of the problem was the four values of the first slide and was at a minimum.

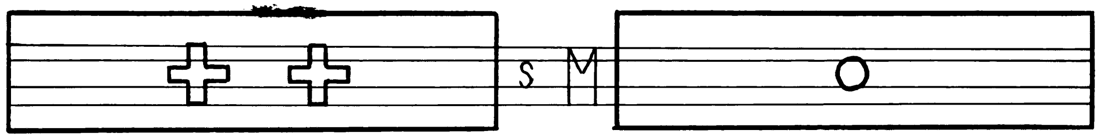
Sequence II - Intermediate-Low "Cognitive Strain" - To provide an intermediate but low amount of "strain", series of slides were prepared, each of which consisted of three slides. The first slide presented one value of the concept, the second slide both values in combination and the last slide the other one value.

(*) Letters were etched on projection window between appropriate guide lines. "S" indicates small, "M" indicates medium. Examples are two-thirds of actual size.

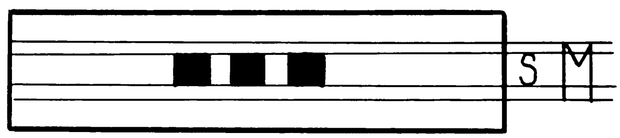
Example of Sequence II*

First Slide

Second Slide




Last Slide




Open Figures Denote Red

Solid Figures Denote Black

Concept: Red - small

There was an increase in the total amount of information to ten dimension values for Sequence II as compared to the six dimension values in Sequence I. In the example, the six values present in Sequence I were increased to a total of ten values in Sequence II by the addition of the four values - two, medium, cross and black.

The same minimum interposing information existed for Sequence II as for Sequence I since there were no interposing slides between the initial presentation of an intended value and its confirmation.

The amount of information that must be stored until the final

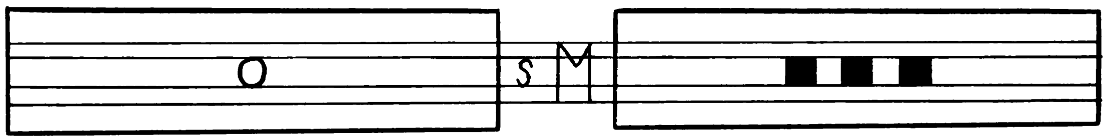
(*) In describing the construction of the five sequences, the identical concept identification task has been used for purposes of clarification. In the actual experiment, different tasks were involved as explained in the design and preparation of slides.

confirmation was increased from four to seven values with the addition of the third slide. In Sequence I the four values of only one slide must be stored until final confirmation. In Sequence II, the values of two slides must be stored before the final confirmation. Although each of the first two slides presents four dimension values, one of the values in this sequence occurred in both the first and second slides (in the example it is the value red). The effect is that a total of seven values was required to be stored in Sequence II, which is an increase from the four values required to be stored in Sequence I.

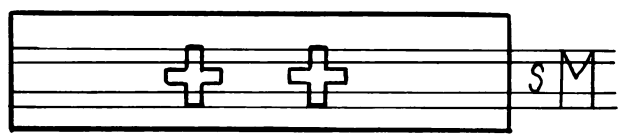
Sequence III - Intermediate-Median "Cognitive Strain" - To provide a further increase in "cognitive strain", series of slides were prepared, each of which consisted of three slides as in Sequence II. In this third sequence, however, the first slide presented both intended dimension values in combination, the second slide presented one value of the concept and the last slide presented the other value of the concept.

Example of Sequence III

First Slide — Second Slide




Last Slide




Open Figures Denote Red
Solid Figures Denote Black

Concept: Red - small

The total amount of information presented was the same for Sequence III as for Sequence II since the identical number of slides containing identical amounts of information were used.

An increase in "cognitive strain" was produced by an increase in the interposing information for one value of the concept. In the example, it is the value red which is observed originally in the first slide but not confirmed until the last slide with the second interposing slide causing the interference.

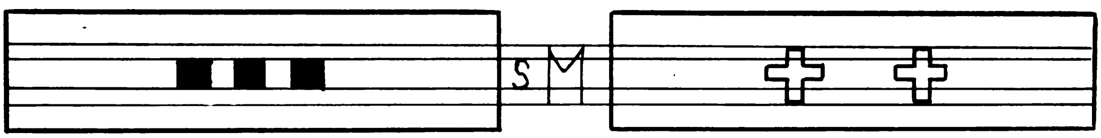
The amount of information that must be stored during the problem was the same (a total of seven dimension values) for Sequence III as for Sequence II.

Sequence IV - Intermediate-High "Cognitive Strain" - To provide

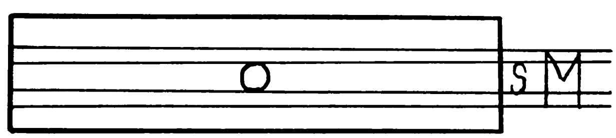
the intermediate-high "strain", series of slides were prepared which again consisted of three slides as in Sequences II and III. In the fourth sequence, however, the first slide presented one value of the concept, the second slide presented the other value of the concept and the last slide presented a combination of both values of the concept.

<u>Example of Sequence IV</u>

First Slide Second Slide




Last Slide




Open Figures Denote Red
Solid Figures Denote Black

Concept: Red - small

The total amount of information presented was the same for Sequence IV as for Sequences II and III since the same number of slides was used.

The same interposing information existed for Sequence IV as for Sequence III. There was no interference for one concept value (in the example, the value red) and an interposing slide between the original observation and its confirmation for the other concept value. (In the example, the value small).

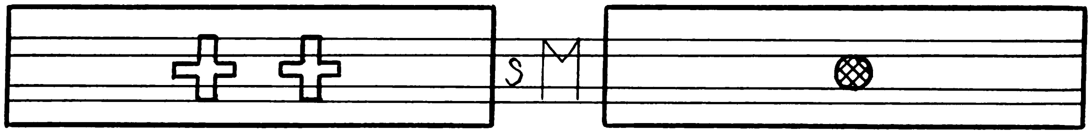
An increase in "cognitive strain" was produced by an increase in the amount of information that must be stored during the problem. In Sequences II and III, the first slide presents four values and the second slide duplicates one value but presents three new values for a total of seven. In series of slides of Sequence IV, the first and second slides each present four different dimension values for a total of eight.

It was the increased number of dimension values to be stored in Sequence IV (eight) compared to Sequences II and III (seven) which increased the "cognitive strain" of Sequence IV.

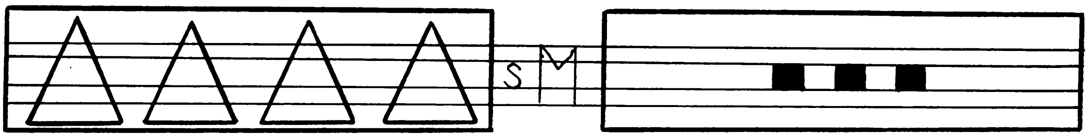
Sequence V - Most "Cognitive Strain" - To provide the most "strain", series of slides were prepared which consisted of four slides each presenting one value of the intended concept. That value which occurred in the first slide was repeated in the third slide. The other value appeared in the second and last slides.

**Example of Sequence V**

First Slide — Second Slide




Third Slide — Last Slide




Open Figures Denote Red
Solid Figures Denote Black
Cross-hatch Figure Denotes Green

Concept: Red - small

There was an increase in the total amount of information presented by the addition of a fourth slide, from ten dimension values observed in Sequences II, III and IV to fourteen dimension values in Sequence V (in the example, the additional values are green, large, triangle and four).

An increase of interposing information occurred in Sequence V for both concept values, as compared to just one value for Sequences II, III and IV, have a slide interposed between the original observation of the value and its confirmation. In the example, the value red is observed in the first slide but not confirmed until the third slide. The value small is observed in the second slide and confirmed in the last slide.

The amount of information that must be stored during the problem was increased with the addition of the fourth slide from a total of eight for Sequence IV to eleven for Sequence V.

Design and Preparation of Slides

The criterion applied in the design of the slides was to develop sequences which would be of equal difficulty in all respects but that of "cognitive strain" for the five types of sequences. For this reason, a master guide was developed of all combinations of two relevant dimensions out of the possible four dimensions. The relevant dimensions were then assigned values in rotation to prevent duplications. The remaining irrelevant dimensions were assigned values randomly except to avoid duplications. The master guide is shown as Appendix II.

Using the master guide to select dimension values, each stimulus figure was drawn on tracing paper with India ink. The sizes of the figures were designed to be in proportion on the basis of the relativity of judgment of sensation contained in Weber's Law and were 3 mm. for tiny, 6 mm. for small, 12 mm. for medium and 24 mm. for the large. Actual production provided some shrinkage in size which did not reduce the distinguishableness of the four sizes. The appropriate Diazochrome sheet (Appendix VI) was processed according to the directions of the Technifax Corporation to produce stimulus figures in the colors green, red, black and orange. The colors were selected on the basis of an array which created the most distinguishable differences

of the materials available. The processed Diazochrome was cut and mounted on the rear of 50 x 150 mm. cardboard with a 25 x 100 mm. window. This slide, when projected on the screen, created an instance in the experiment. A detailed record of all dimension values of each slide in each sequence and the order of presentation is in Appendix III.

The procedure of systematically assigning a combination of relevant dimensions and randomizing the assignment of irrelevant values was an attempt to equalize difficulty inherent in any particular dimension value. However, it was possible to further control the effects of variations of dimension values for Sequences II, III and IV since they contained the same number of slides. These three sequences differed only in the position of the slide presenting both values of the concept in combination. Therefore, by rotating the order of presenting the slides in a sequence (as was done with the example used to describe the development of the five sequences), it was possible to change the type of sequence. By changing the type of sequence among three groups of subjects, any confounding difficulty of dimension values could be counter-balanced among the three types of sequences. For example, in Group A an example of Sequence II would have the slide containing both values of the concept occurring in the second slide. By presenting the slide containing both values of the concept slide first to Group B, this sequence became an example of Sequence III. Further rotation in Group C would present the slide containing both values of the concept in the third slide, an example of Sequence IV.

This possibility suggested the use of three groups of subjects in the experiment.

The result of the rotation was that a particular sample of a sequence was used as an example of Sequences II, III and IV for each of three groups of subjects. If the particular combination of values were especially easy or difficult to identify, the effect would be distributed through the three different types of sequences.

This added control was not feasible, of course, for Sequences I and V since they contain a different number of slides.

Another problem to be considered in the design of the experiment was the order of presentation of the sequences. The plan used was to randomize the order of sequences within a set containing one of each type of sequence. This procedure was followed for the first half of the total presentations. The second half of the presentations was the reverse of the first half to give a counter-balancing effect. Each example from the master guide was randomly assigned to the planned presentation. Sequence II was not added until after the master guide was originally developed so it does not follow completely the systematic pattern of assignment of values as used in the original development of the master guide. However, any effect from the deviation was randomized by the rotation procedure.

A final factor considered was the number of slides to be used. It was felt that fatigue would influence the results if the actual

testing exceeded thirty minutes. Six examples of each type of sequence, one of each possible combination of dimensions, were used. The final testing time ran 22½ minutes.

## Subjects

The subjects were members of three Introductory Psychology classes at Flint Community Junior College. In the analysis to follow, these classes are identified as Groups A, B and C. All groups were tested in the same room, using the same equipment and slides and it is felt that the testing conditions were the same for all subjects. However, since these conditions could have differed in some unknown way, the group effect was studied as a factor in the statistical analysis of the experiment.

## Equipment

The projecting equipment was a Vu-Graph overhead projector on a podium placed nine feet from the wall-mounted, 72" x 84" DaLite screen. The platen of the projector was covered with construction paper except for a window (30 x 105 mm.) slightly larger than the slides (25 x 100 mm.). Guide lines to enable accurate determination of the figure's size were etched on the window. A stop on the mat accurately positioned each slide in the window.

## Procedure

In conducting the experiment, the window drapes were closed and one-half of the overhead fluorescent lights were turned on. In

this way the room lighting was controlled for each group. This arrangement, while reducing the overall room light intensity to permit clear viewing of the projected figures, provided adequate lighting for the subjects to see as they wrote their responses.

A response sheet (Appendix V), which identified the dimensions and their values at the top, was distributed to each subject. On the response sheet were double lines for each "rule", one for writing each value of the concept to be identified. The use of the response sheet was explained and demonstrated during an instruction period. When all subjects indicated they understood the task and how to use the response sheet, the experimenter installed the first slide, indicating that there were two (three or four) slides in that sequence. The assistant (*) turned on the projector for seven seconds and then turned it off for three. During the three seconds that the screen was dark, the assistant removed the slide that had been shown, the experimenter installed the next slide and indicated to the subjects the appropriate number of the next slide. The same procedure was repeated for the remaining slides in a sequence.

After the last slide in a sequence was shown, the experimenter said "write the rule", the assistant removed the last slide and the experimenter installed the first slide of the next sequence. After the screen had been dark for thirteen seconds, the experimenter said

(*) The assistant was an experienced laboratory assistant at the Flint College, University of Michigan. His task was to control the rate and pace of exposure by observing a stop watch.

"there are two (three or four) slides in this sequence, number one". The assistant turned on the projector five seconds later, and the routine was repeated for all thirty sequences. The procedure was the same for each group except the order of presenting the slides was rotated so that a particular sequence which was an example of Sequence II for Group A became Sequence III for Group B, and became Sequence IV for Group C.

The Otis Quick-Scoring Mental Ability Test, Gamma Test: Form Em (30 minute), was administered to Group C immediately after the experiment and during a later class session for Groups A and B.

# CHAPTER V

## ANALYSIS OF RESULTS

To evaluate the effect of the five types of sequences designed to achieve an increasing amount of "cognitive strain" in concept identification, an analysis of variance design was used.

The general plan to test the hypothesis was to administer six examples of each of the five degrees of "cognitive strain" to all subjects. With each of the original set of eighty-four subjects responding under all five conditions, the effects of individual subject differences were balanced across the different types of sequences. Repeated measurements at each level of "cognitive strain" resulted and the experimental design used in the analysis made provision for this (18, p. 337).

In addition to the effects of the types of sequences, a second important main effect was evaluated. To obtain an adequate number of subjects, and to permit balancing examples in Sequences II, III and IV, three groups of subjects were tested. The differences that might arise in the separate administration of the experiment to these three groups were controlled as far as it was possible to do so. But to estimate the effect of uncontrolled differences in the groups, the class membership of the subjects was included as a factor to be evaluated by the design.

A third factor, intelligence, was evaluated as the third main effect in the analysis of variance. Scores from an administration of Gamma Test: Form Em of the Otis Quick-Scoring Mental Ability Test were used to partition each of the three groups into three intelligence levels. The partitioning was made at the mean for all subjects plus and minus one-half standard deviation.

The mean was 113.92 for all subjects with a standard deviation equal to 10.63. Partitioning produced a "low" level with I.Q.'s equal to 108 or below, a "mid" level with I.Q.'s ranging from 109 through 119 and a "high" level with I.Q.'s 120 and above. This division resulted in an unequal number of subjects in the nine combinations of group membership and I.Q. level. Proportionality was obtained by systematically casting out fifteen of the original eighty-four cases. Since it was desirable to maintain the original I.Q. distributions, the I.Q. scores were first ranked within each combination of group and level. The 4th and 8th ranks were then removed from the combination Group C - High I.Q.; the 5th rank from Group B - Mid I.Q.; the 3rd, 6th and 9th ranks from Group C - Mid I.Q.; the 2nd and 6th ranks from Group A - Low I.Q.; and the 1st, 3rd, 5th, 7th, 9th, 11th and 12th ranks from Group B - Low I.Q.

The revised groups were equal in size, twenty-three cases each, consisting of five subjects in each group at the intelligence-low level, nine subjects in each group in the intelligence-mid level, and nine subjects in each group in the intelligence-high level, for a total of sixty-nine subjects.

The resulting matrix provided a 5 x 3 x 3 analysis of variance design with sequences, groups and ability levels as the main treatment with repeated measurements on the sequences.

Attainment of one-half the correct answer was not considered as correct identification of the concept on the response sheet. Therefore, the response sheets were scored by indicating as incorrect all concepts (rules) that were found one-half or entirely wrong. The total number of correct answers was recorded on data sheets (Appendix I).

The means and standard deviation on the dependent variable, "correct" concept identification, for the analytic matrix are summarized in Table 1.

TABLE 1

MEAN NUMBER OF CONCEPTS IDENTIFIED

AND STANDARD DEVIATIONS

| | | SEQUENCES | | | | | |
|---|---|---|---|---|---|---|---|
| GROUP A | | I | II | III | IV | V | TOTAL |
| Intelligence-Low | M | 5.20 | 3.80 | 3.80 | 2.60 | 1.60 | 3.40 |
| | SD | .74 | 1.16 | .40 | 1.35 | .80 | 1.60 |
| Intelligence-Mid | M | 4.77 | 4.88 | 4.22 | 3.66 | 1.80 | 3.88 |
| | SD | .78 | .99 | 1.13 | .81 | .62 | 1.29 |
| Intelligence-High | M | 5.77 | 5.00 | 4.77 | 4.33 | 3.22 | 4.62 |
| | SD | .62 | 1.15 | .78 | 1.56 | 1.54 | 1.44 |
| TOTAL | M | 5.26 | 4.69 | 4.34 | 3.69 | 2.34 | |
| | SD | .84 | 1.10 | .96 | 1.45 | 1.31 | |

| GROUP B | | I | II | III | IV | V | TOTAL |
|---|---|---|---|---|---|---|---|
| Intelligence-Low | M | 5.20 | 4.40 | 4.60 | 4.40 | 2.20 | 4.16 |
| | SD | 7.48 | 1.20 | 1.01 | 1.01 | .40 | 1.37 |
| Intelligence-Mid | M | 5.11 | 4.88 | 4.33 | 4.44 | 2.77 | 4.31 |
| | SD | 1.28 | .99 | .93 | .82 | 1.13 | 1.36 |
| Intelligence-High | M | 5.88 | 5.44 | 4.88 | 5.33 | 3.33 | 4.97 |
| | SD | .30 | .49 | .30 | 1.23 | 1.94 | 1.05 |
| TOTAL | M | 5.43 | 5.00 | 4.60 | 4.78 | 2.87 | |
| | SD | .97 | .97 | .82 | 1.21 | 1.43 | |

TABLE 1 (Continued)

| GROUP C | | SEQUENCES I | II | III | IV | V | TOTAL |
|---|---|---|---|---|---|---|---|
| Intelligence-Low | M | 5.60 | 4.40 | 4.00 | 2.00 | 1.60 | 3.52 |
| | SD | .48 | .80 | .63 | 1.41 | 1.03 | 1.50 |
| Intelligence-Mid | M | 5.44 | 4.66 | 4.22 | 3.44 | 2.55 | 4.06 |
| | SD | .68 | 1.05 | .91 | 1.16 | .95 | 1.38 |
| Intelligence-High | M | 5.77 | 5.00 | 5.44 | 4.33 | 2.77 | 4.66 |
| | SD | .41 | .66 | .64 | .81 | 1.13 | 1.31 |
| TOTAL | M | 5.16 | 4.74 | 4.65 | 3.47 | 2.43 | |
| | SD | .57 | .89 | 1.00 | 1.24 | 1.05 | |

| | | SEQUENCES I | II | III | IV | V |
|---|---|---|---|---|---|---|
| TOTALS | M | 5.43 | 4.81 | 4.53 | 3.98 | 2.55 |
| | SD | .82 | 1.00 | .94 | 1.37 | 1.31 |

| INTELLIGENCE LEVEL | | SEQUENCES I | II | III | IV | V | TOTAL |
|---|---|---|---|---|---|---|---|
| Low | M | 5.33 | 4.20 | 4.13 | 3.00 | 1.80 | 3.69 |
| | SD | .69 | 1.10 | 8.06 | 1.63 | .78 | 1.51 |
| Mid | M | 5.11 | 4.81 | 4.26 | 3.85 | 2.40 | 4.09 |
| | SD | .99 | .94 | 1.00 | 1.10 | .99 | 1.35 |
| High | M | 5.81 | 5.15 | 5.03 | 4.06 | 3.11 | 4.75 |
| | SD | .79 | .82 | .69 | 1.43 | 1.51 | 1.30 |

TOTALS

| | GROUP A | GROUP B | GROUP C | GRAND |
|---|---|---|---|---|
| M | 4.07 | 4.54 | 4.18 | 4.26 |
| SD | 1.49 | 1.33 | 1.41 | 1.43 |

<u>Assumptions</u>

One necessary assumption for use of the analysis of variance design is that homogeneity within cells exists.

To test for homogeneity within cells, F max tests were made (18, p. 339). The computations indicated that the (a) between subjects in groups F max equaled 4.02 where the required critical F max $_{.95}$ with nine and eight degrees of freedom is equal to 11.10 and that the (b) within subjects in groups F max equaled 4.03 with the required critical F max $_{.95}$ with nine and eight degrees of freedom equaling 5.15. Neither of the computed error terms exceeded its F ratio critical value at the .95 level and indicated that acceptance of the assumption of homogeneity within cells was warranted.

The repeated measurement design used also assumes homogeneity of covariance. A test for this assumption is given by Winer (18, p. 369). The computation of a covariance matrices $\chi^2$ equaled 241.29; required critical value $\chi^2_{.95}$ with thirty degrees of freedom equaled 43.80. The computed $\chi^2$ exceeding the required critical value indicated that symmetry in the covariance matrices did not exist. For this reason, the conservative tests of Greenhouse and Geisser (6) have been used which avoids assumptions about equal covariances in the pooled variance-covariance matrix.

The use of repeated measurements design also assumes that the order of administration is randomized (16). The confounding effects

that might result from position were minimized by several procedures. The order of the presentation was in sets of the five sequences with positions of the sequences within each set randomized. The second half of all the groups was presented in the reverse order of the first half. In this way, each sequence position was counter-balanced in its presentation.

Six examples of each type of sequence were used. This permitted the use of one example of each of the possible combinations of relevant dimensions (combinations of two relevant dimensions from among four possible dimensions), and thus balanced possible effects of particular combinations of dimensions in the tasks.

A further control over effects of the use of particular dimension values in sequences was possible for Sequences II, III and IV since the tasks in these sequences were identical except for the order of the slides within each sequence. The order of presenting the slides for these sequences was rotated among the three groups of subjects to change the type of sequence. A sequence of slides which was an example of Sequence II for Group A became Sequence III for Group B by starting with the second slide. This same example became Sequence IV for Group C by starting with the third slide. By the rotation, possible variations in difficulty of dimension values was balanced for Sequences II, III and IV. No other modification in the order of presenting the slides was made. It was felt that any other change would confound the order and reduce the value of the rotation control.

Since Sequences I and V required a different number of slides, such a control was not feasible with respect to these sequences. Therefore, the stringent .01 level was set for determining significance of main effects and interactions on the dependent variable.

## Results

The results of the analysis of the data are summarized in the following Analysis of Variance table (Table 2). The conservative tests were used to determine the probability of obtaining the observed F's in those tests involving repeated measurement of the sequences. The critical values are shown for the two F ratios which turned out to be statistically significant.

TABLE 2

SUMMARY OF ANALYSIS OF VARIANCE

| Source of Variation | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Between Subjects | 243.40 | 68 | | | |
| Groups | 13.81 | 2 | 6.90 | 2.49 | |
| Intelligence | 61.18 | 2 | 30.59 | 11.04 | F = 4.98 .99 (2,60) |
| Groups x intelligence | 1.96 | 4 | .49 | .18 | |
| Subjects within groups (Between error) | 166.45 | 60 | 2.77 | | |
| Within Subjects | 550.60 | 276 | | | |
| Sequence | 328.27 | 4 | 82.07 | 106.58 | F = 7.08 (*) .99 (1,60) |
| Groups x sequences | 16.13 | 8 | 2.01 | 2.61 | |
| Intelligence x sequences | 10.72 | 8 | 1.34 | 1.74 | |
| Groups x intelligence x sequences | 10.66 | 16 | .66 | .86 | |
| Sequences x subjects Within Groups (Within error) | 184.82 | 240 | .77 | | |

(*) Conservative test using reduced d.f. (6)

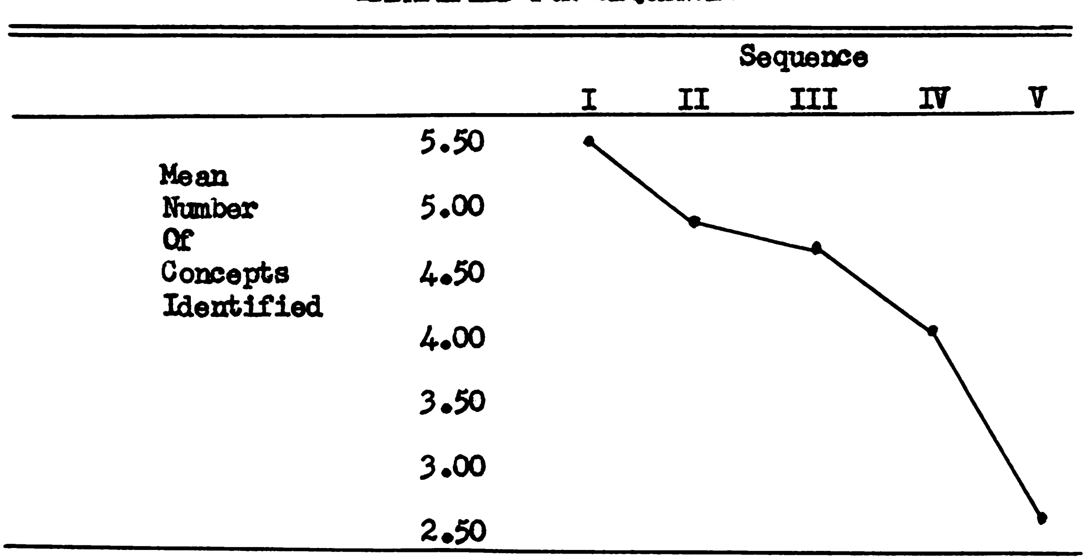
## Significant Factors

The difference in concept identification scores attributable to two of the main factors proved to be statistically significant at the .01 level.

The "cognitive strain" presentation sequences were indicated to be most significant and the hypothesis was judged to be supported by the experiment. The mean number of concepts correctly identified in each of the five sequences followed the predicted pattern of an inverse relationship between the amount of "cognitive strain" and the effectiveness of concept identification. A graph in which the mean number of concepts identified was plotted against the five sequences illustrated the inverse relation (Table 3).

TABLE 3

GRAPH OF MEAN NUMBER OF CONCEPTS IDENTIFIED FOR SEQUENCES



A further analysis using Duncan's Multiple Range Test (4) showed statistically significant differences at the .01 level between the concepts identified in all comparisons of types of sequences except between Sequences II and III (Intermediate-low and intermediate-median degrees of "cognitive strain").

TABLE 4

DUNCAN'S MULTIPLE RANGE TEST OF SEQUENCES

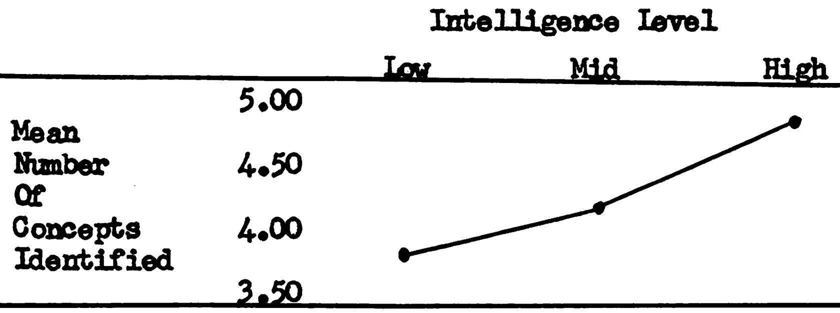
| | | Mean of Concepts Identified by Sequence | | | | | Shortest Significant Ranges |
|---|---|---|---|---|---|---|---|
| | | V | IV | III | II | I | |
| | | 2.55 | 3.98 | 4.53 | 4.81 | 5.43 | $\alpha = .01$ |
| V | 2.55 | | 1.43 | 1.98 | 2.26 | 2.88 | $R_2 = .38$ |
| IV | 3.98 | | | .55 | .83 | 1.45 | $R_3 = .40$ |
| III | 4.53 | | | | .28 | .90 | $R_4 = .41$ |
| II | 4.81 | | | | | .62 | $R_5 = .42$ |

Sequences Underscored Are Not Significant

Differences in intelligence levels were found to be statistically significant at the .01 level. The mean of the number of concepts identified for the three levels of intellectual ability followed the positive relationship predicted between intelligence and concept identification. A graph of the mean number of concepts correctly identified plotted against the three levels of intelligence illustrated the relationship (Table 5).

TABLE 5

GRAPH OF MEAN NUMBER OF CONCEPTS IDENTIFIED
AT INTELLIGENCE LEVELS




A further analysis using Kramer's modification for unequal n's of the Duncan Multiple Range Tests (11) indicated that significant differences existed only between the high and mid, and high and low intelligence levels.

TABLE 6

DUNCAN'S MULTIPLE RANGE TEST WITH KRAMER'S
MODIFICATION FOR UNEQUAL n's OF INTELLIGENCE LEVELS

| | | Mean Number of Concepts Identified By Intelligence Level | | | Shortest Significant Ranges |
|---|---|---|---|---|---|
| | | Low | Mid | High | |
| | | 3.69 | 4.09 | 4.75 | $\alpha$ = .01 |
| Low | 3.69 | | 3.92 | 10.40 | $R_2 = 6.24$ |
| Mid | 4.09 | | | 7.66 | $R_3 = 6.52$ |

Levels Underscored Are Not Significant

The analysis suggested that the order of the relationship between levels of intellectual ability and concept identification was in the order predicted. However, this conclusion is statistically reliable for these data only for the comparison of the high-mid and high-low intelligence levels.

Variance of the groups and the interaction effects of sequences, groups and intelligence levels did not prove to be statistically significant, indicating extraneous variables were controlled or randomized.

## CHAPTER VI

## SUMMARY AND DISCUSSION OF FINDINGS

A search for an explanation of variations in effectiveness of presentation sequences used as guidance in the concept identification task initiated the present investigation.

The amount of "cognitive strain" induced by the sequences was postulated from past research as a possible explanatory principle. "Cognitive strain" in an identification task was developed in five ascending degrees by manipulating three conditions: (a) total amount of information presented for observation, (b) amount of interposing information and (c) amount of information to be stored during the solution of a problem. Three groups of Introductory Psychology students were used as subjects in the study. Each subject attempted six examples of each of the five degrees of "cognitive strain". Identifications were scored for the number correctly made by each subject.

An analysis of variance of the main effects of group membership, intelligence levels, and presentation sequences was made with repeated measurements on the sequences. The results showed a decreasing number of concepts correctly identified in each sequence when the latter were ordered for increasing "cognitive strain". Differences were statistically significant for the comparison of adjacent sequences in three of the possible four comparisons.

The data supported the hypothesis of an inverse relationship existing between amount of "cognitive strain" and effectiveness in concept identification.

The hypothesis that a positive relationship between intelligence and concept identification would be found also appeared statistically warranted. No significant interactions between the main effects were discerned.

Interpretation of Findings

Intelligence proved to be a significant factor with a positive relationship to concepts attained. This is to be expected on the basis that an I.Q. score is reflecting the ability of the subject to deal with concepts and symbols and indicates validity of the concept task. It was found that the significant differences were between only the high and low, and high and mid levels, of I.Q. scores. The factor which may have prevented greater differences from developing between the low and mid levels is a selective intelligence factor of the subjects who as college students are intellectually a select group. A "basement effect" resulted in a skewed distribution as indicated by the number of cases in the proportional intelligence levels. The result was that the low intelligence level contained a smaller number of cases than the mid and high levels. The actual range of the center level was only ten I.Q. points and due to the overlapping of levels that would occur from variations in testing, combined with the smaller number of cases, no statistically significant differences between mid and low levels developed.

Non-significant findings for group effects is interpreted to indicate that differences that may have existed between the groups were not great enough to influence the results. Non-significance of the interaction effects is taken to mean that all other variables were adequately randomized or controlled.

The three conditions which were used to increase "cognitive strain" occurred in combinations except in the comparison of Sequence II with Sequence III. The condition that distinguished Sequence II from Sequence III was based on the assumption that interposing information would increase cognitive activity. The assumption developed from the interpretation of the conclusions of Bruner, et al, and the evidence presented by Hunt. The evidence found in the present study conflicting with that found by Hunt reflects the difficulty that exists in measuring and manipulating "cognitive strain". It is possible that the amount of interposing information in this comparison was not great enough to cause a noticeable increase in cognitive activity.

It would be possible in an experiment of four slide problems, in which each slide contained a single correct dimension value, to arrange the order of the slides to obtain different amounts of interposing information. Such an investigation could confirm the work of Hunt for the type of concept task used in the present investigation. In any case, further investigation of the contradictory evidence may be one of the most fruitful areas to achieve a clearer understanding

of the relationship between "cognitive strain" and concept identification.

The important contribution of this study was the defining and testing of "cognitive strain" and the inverse relationship to concept identification. In so doing, a basis was verified for estimating and manipulating "cognitive strain" on the assumptions of the subject's encoding which was suggested but not tested by Glanzer (5). The value of the evidence lies in its use in analyzing presentations to achieve the maximum concept identification.

Programed learning is an example of where the idea of "cognitive strain" may be applied to a concept identification task. A sample of programed material is as follows:

| | |
|---|---|
| behavior | "1. By behavior the psychologist means those acts that can be observed by another person or by an experimenter's instruments. When we observe a child crying, we are observing ____________. |
| observing (or measuring) | 2. If we measure breathing rate by use of instruments, we are ________ behavior. |
| behavior | 3. When we give a test to a person and then grade that test, we are observing ____________." (16) |

It can be observed in this sample that examples are used in short direct statements with a minimum amount of "cognitive strain" as in Sequence I of the experiment. There is a minimum amount of interposing information since the response follows closely the introduction of the concept in each frame. Another condition

contributing to low "cognitive strain" is the low amount of storage information that must be stored before confirmation due to the small steps, similarity of ideas and context. With low "cognitive strain", concept identification is maximized and learning proceeds rapidly.

Is there a disadvantage to low "cognitive strain"? Frequently learners demonstrate rapid effective learning from programed material but often they don't like it. The low "cognitive strain" of programing results in a balanced situation with everything running smoothly so that a state of discontent develops. It may be conjectured that a teacher, in making concept attainment most effective, may also create discontentment and lessen motivation.

Finally, in the present study three presentation conditions were found to vary "cognitive strain" while in the studies by Bruner, et al, it was found that strategies could vary "cognitive strain". On the basis of the evidence and procedures used to manipulate "cognitive strain" in the present investigation, it is now possible and certainly desirable to conduct an investigation with variations in both presentation conditions and strategies as studied by Bruner, et al, to evaluate the effect on concept identification of the interaction of these variables which have been evaluated independently.

# APPENDIX I

## DATA SHEETS

| Subject Code Number | Correct Identifications of Sequence | | | | | |
|---|---|---|---|---|---|---|
| Group A | I | II | III | IV | V | I.Q. |
| (1) | 6 | 6 | 5 | 4 | 3 | 105 |
| 2 | 6 | 6 | 4 | 4 | 1 | 113 |
| 3 | 5 | 3 | 3 | 4 | 2 | 117 |
| 4 | 6 | 5 | 6 | 4 | 3 | 134 |
| 5 | 4 | 3 | 4 | 3 | 1 | 103 |
| 6 | 6 | 2 | 5 | 1 | 1 | 125 |
| 7 | 6 | 6 | 5 | 6 | 6 | 121 |
| 8 | 5 | 5 | 6 | 5 | 3 | 111 |
| 9 | 5 | 3 | 3 | 2 | 2 | 107 |
| 10 | 4 | 5 | 4 | 5 | 3 | 113 |
| 11 | 6 | 6 | 4 | 5 | 5 | 135 |
| 12 | 5 | 5 | 5 | 3 | 3 | 112 |
| 13 | 4 | 5 | 5 | 3 | 2 | 112 |
| (14) | 0 | 2 | 2 | 1 | 1 | 92 |
| 15 | 4 | 5 | 2 | 3 | 0 | 109 |
| 16 | 6 | 6 | 4 | 5 | 3 | 103 |
| 17 | 6 | 5 | 6 | 5 | 4 | 129 |
| 18 | 6 | 5 | 4 | 4 | 2 | 123 |
| 19 | 4 | 5 | 5 | 6 | 2 | 126 |
| 20 | 6 | 5 | 5 | 3 | 1 | 109 |
| 21 | 6 | 4 | 4 | 2 | 1 | 102 |
| 22 | 4 | 5 | 4 | 3 | 2 | 111 |
| 23 | 5 | 3 | 4 | 1 | 1 | 85 |
| 24 | 6 | 6 | 4 | 3 | 2 | 126 |
| 25 | 6 | 5 | 4 | 5 | 4 | 121 |

( ) Indicates a case which was cast out in the proportionalizing of the intelligence levels of groups.

APPENDIX I (Continued)

| Subject Code Number | Correct Identifications of Sequence | | | | | |
|---|---|---|---|---|---|---|
| Group B | I | II | III | IV | V | I.Q. |
| 26 | 6 | 4 | 3 | 5 | 2 | 114 |
| 27 | 6 | 6 | 5 | 6 | 6 | 121 |
| (28) | 6 | 4 | 6 | 6 | 4 | 106 |
| 29 | 6 | 4 | 5 | 4 | 4 | 109 |
| (30) | 5 | 5 | 5 | 4 | 2 | 103 |
| 31 | 6 | 6 | 5 | 5 | 5 | 122 |
| (32) | 5 | 3 | 6 | 4 | 3 | 99 |
| 33 | 4 | 3 | 5 | 4 | 2 | 96 |
| (34) | 6 | 6 | 5 | 6 | 4 | 112 |
| 35 | 6 | 6 | 4 | 6 | 3 | 102 |
| 36 | 6 | 5 | 6 | 5 | 3 | 114 |
| 37 | 6 | 5 | 5 | 6 | 0 | 125 |
| 38 | 4 | 6 | 5 | 2 | 3 | 109 |
| 39 | 6 | 5 | 5 | 5 | 2 | 100 |
| 40 | 2 | 3 | 4 | 4 | 1 | 119 |
| 41 | 5 | 5 | 3 | 6 | 2 | 110 |
| 42 | 5 | 5 | 4 | 5 | 2 | 111 |
| 43 | 5 | 5 | 6 | 3 | 2 | 104 |
| (44) | 5 | 5 | 4 | 4 | 3 | 101 |
| (45) | 3 | 3 | 3 | 2 | 4 | 97 |
| 46 | 6 | 5 | 5 | 5 | 3 | 127 |
| 47 | 6 | 6 | 5 | 6 | 6 | 124 |
| 48 | 6 | 5 | 5 | 6 | 3 | 123 |
| 49 | 6 | 6 | 5 | 4 | 3 | 114 |
| 50 | 6 | 5 | 5 | 6 | 1 | 127 |
| 51 | 6 | 6 | 4 | 5 | 5 | 117 |
| 52 | 5 | 5 | 5 | 6 | 3 | 132 |
| 53 | 6 | 6 | 4 | 2 | 3 | 120 |
| (54) | 5 | 4 | 4 | 3 | 4 | 106 |
| (55) | 5 | 4 | 5 | 4 | 4 | 92 |
| 56 | 5 | 3 | 3 | 4 | 2 | 98 |

APPENDIX I (Continued)

| Subject Code Number | Correct Identifications of Sequence | | | | | |
|---|---|---|---|---|---|---|
| Group C | I | II | III | IV | V | I.Q. |
| 57 | 6 | 5 | 5 | 2 | 1 | 110 |
| 58 | 6 | 6 | 4 | 5 | 2 | 118 |
| 59 | 5 | 3 | 5 | 4 | 2 | 112 |
| 60 | 5 | 4 | 4 | 4 | 4 | 117 |
| (61) | 6 | 4 | 5 | 3 | 4 | 113 |
| 62 | 6 | 4 | 6 | 5 | 2 | 135 |
| 63 | 6 | 5 | 4 | 2 | 1 | 100 |
| 64 | 6 | 5 | 6 | 6 | 3 | 120 |
| 65 | 5 | 5 | 4 | 2 | 2 | 119 |
| 66 | 4 | 3 | 2 | 2 | 3 | 113 |
| 67 | 5 | 5 | 4 | 0 | 3 | 106 |
| 68 | 5 | 3 | 4 | 4 | 1 | 106 |
| 69 | 6 | 5 | 4 | 4 | 2 | 116 |
| (70) | 4 | 3 | 5 | 4 | 2 | 127 |
| (71) | 6 | 4 | 4 | 5 | 3 | 117 |
| 72 | 6 | 5 | 6 | 5 | 3 | 135 |
| 73 | 6 | 4 | 5 | 4 | 1 | 121 |
| 74 | 6 | 6 | 4 | 4 | 4 | 120 |
| 75 | 6 | 6 | 5 | 5 | 4 | 115 |
| 76 | 6 | 4 | 3 | 1 | 0 | 103 |
| 77 | 6 | 5 | 5 | 3 | 3 | 103 |
| 78 | 6 | 5 | 5 | 4 | 1 | 124 |
| 79 | 6 | 6 | 5 | 4 | 4 | 128 |
| (80) | 4 | 2 | 4 | 0 | 1 | 115 |
| 81 | 5 | 5 | 6 | 3 | 3 | 120 |
| 82 | 6 | 5 | 5 | 3 | 3 | 117 |
| (83) | 5 | 5 | 4 | 5 | 2 | 120 |
| 84 | 5 | 5 | 6 | 4 | 4 | 122 |

# APPENDIX II

## MASTER GUIDE FOR DIMENSION VALUES

| Dimensions | | Values | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| A | Size: | Large | Medium | Small | Tiny |
| B | Color: | Orange | Green | Black | Red |
| C | Form: | Round | Triangular | Cross | Square |
| D | Quantity: | One | Two | Three | Four |

Capital letters indicate the concept dimensions. Lower case letters indicate irrelevant dimensions.

| | | First Slide | Second Slide | Third Slide | Fourth Slide |
|---|---|---|---|---|---|
| I | | | | | |
| | 1 | A4 B2 c2 d1 | A4 B2 c3 d2 | | |
| | 2 | A3 C2 b4 d4 | A3 C2 b3 d3 | | |
| | 3 | A2 D1 b2 c4 | A2 D1 b1 c1 | | |
| | 4 | B1 C3 a1 d1 | B1 C3 a2 d2 | | |
| | 5 | B3 D2 a2 c3 | B3 D2 a1 c2 | | |
| | 6 | C1 D3 a3 b3 | C1 D3 a4 b4 | | |
| III | | | | | |
| | 7 | A1 B4 c2 d4 | B4 a2 c3 d3 | A1 b2 c1 d2 | |
| | 8 | A4 C4 b4 d1 | A4 b3 c3 d2 | C4 a2 b1 d3 | |
| | 9 | A3 D4 b1 c1 | D4 a2 b3 c3 | A3 b2 c4 d2 | |
| | 10 | B2 C2 a2 d2 | B2 a1 c1 d1 | C2 a4 b4 d4 | |
| | 11 | B1 D1 a3 c1 | D1 a4 b4 c4 | B1 a1 c2 d4 | |
| | 12 | C3 D2 a1 b2 | C3 a2 b1 d1 | D2 a4 b4 c4 | |
| IV | | | | | |
| | 13 | B3 a1 c2 d4 | A2 b1 c3 d3 | A2 B3 c1 d2 | |
| | 14 | A1 b3 c4 d1 | C1 a3 b1 d2 | A1 C1 b2 d3 | |
| | 15 | D3 a3 b3 c3 | A4 b4 c2 d2 | A4 D3 b2 c1 | |
| | 16 | B4 a2 c2 d2 | C4 a3 b3 d1 | B4 C4 a1 d3 | |
| | 17 | D4 a4 b1 c1 | B2 a1 c3 d1 | B2 D4 a3 c2 | |
| | 18 | C2 a4 b2 d3 | D1 a1 b1 c1 | C2 D1 a3 b4 | |

## APPENDIX II (Continued

| | | First Slide | Second Slide | Third Slide | Fourth Slide |
|---|---|---|---|---|---|
| V | | | | | |
| | 19 | B1 a2 c3 d2 | A3 b3 c1 d1 | B1 a1 c2 d4 | A3 b2 c4 d3 |
| | 20 | A2 b3 c1 d2 | C3 a4 b1 d4 | A2 b4 c2 d1 | C3 a2 b3 d3 |
| | 21 | D2 a4 b2 c4 | A1 b1 c1 d1 | D2 a3 b3 c3 | A1 b4 c2 d3 |
| | 22 | B3 a2 c2 d1 | C1 a3 b4 d2 | B3 a1 c3 d3 | C1 a4 b2 d2 |
| | 23 | D3 a1 b1 c1 | B4 a3 c3 d4 | D3 a2 b2 c4 | B4 a4 c2 d2 |
| | 24 | C4 a4 b3 d2 | D4 a2 b1 c1 | C4 a3 b4 d3 | D4 a1 b2 C3 |
| II (*) | | | | | |
| | 25 | D2 a1 b1 c1 | C2 D2 a2 b2 | C2 a4 b4 d1 | |
| | 26 | D4 a3 b1 c4 | A2 D4 b3 c3 | A2 b2 c2 d3 | |
| | 27 | D3 a3 b3 c4 | B2 D3 a2 c1 | B2 a4 c3 d1 | |
| | 28 | A4 b2 c1 d2 | A4 C4 b4 d4 | C4 a3 b3 d3 | |
| | 29 | B3 a2 c4 d2 | A4 B3 c1 d1 | A4 b4 c3 d4 | |
| | 30 | C3 a3 b2 d1 | B4 C3 a4 d2 | B4 a2 c2 d4 | |

(*) Sequence II was added after the first trial run and was an addition to the guide.

# APPENDIX III

## DIMENSIONS AND ORDER OF SEQUENCE PRESENTATION

| | | | First Slide | | | | Second Slide | | | | Third Slide | | | | Fourth Slide | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order | Sequence* | Number | Form | Color | Size | Quantity | Form | Color | Size | Quantity | Form | Color | Size | Quantity | Form | Color | Size | Quantity |
| 1 | 5 | 19 | C | O | M | 2 | R | B | S | 1 | T | O | L | 4 | S | G | S | 3 |
| 2 | 2 | 17 | R | O | T | 4 | C | G | L | 1 | T | G | S | 4 | | | | |
| 3 | 3 | 25 | R | O | L | 2 | T | G | M | 2 | T | R | T | 1 | | | | |
| 4 | 4 | 11 | R | O | S | 1 | S | R | T | 1 | T | O | L | 4 | | | | |
| 5 | 1 | 3 | S | G | M | 1 | R | O | M | 1 | | | | | | | | |
| 6 | 2 | 18 | T | G | T | 3 | R | O | L | 1 | T | R | S | 1 | | | | |
| 7 | 4 | 7 | T | R | L | 4 | C | R | M | 3 | R | G | L | 2 | | | | |
| 8 | 1 | 6 | R | B | S | 3 | R | R | T | 3 | | | | | | | | |
| 9 | 3 | 26 | S | O | S | 4 | C | B | M | 4 | T | G | M | 3 | | | | |
| 10 | 5 | 23 | R | O | L | 3 | C | R | S | 4 | S | G | M | 3 | T | R | T | 2 |
| 11 | 3 | 27 | S | B | S | 3 | R | G | M | 3 | C | G | T | 1 | | | | |
| 12 | 4 | 10 | T | G | M | 2 | R | G | L | 1 | T | R | T | 4 | | | | |

Key: Form: C - Cross, R - Round, S - Square, T - Triangle
Color: O - Orange, G - Green, R - Red, B - Black
Size: L - Large, M - Medium, S - Small, T - Tiny

(*) Order shown is for Group A. Due to rotation of presentation in groups, 2 = 3, 3 = 4, 4 = 2 for Group B; 2 = 4, 3 = 2, 4 = 3 For Group C.

## APPENDIX III (Continued)

| | | | First Slide | | | | Second Slide | | | | Third Slide | | | | Fourth Slide | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order | Sequence* | Number | Form | Color | Size | Quantity | Form | Color | Size | Quantity | Form | Color | Size | Quantity | Form | Color | Size | Quantity |
| 13 | 1 | 2 | T | R | S | 4 | T | B | S | 3 | | | | | | | | |
| 14 | 5 | 21 | S | G | T | 2 | R | O | L | 1 | C | B | S | 2 | T | R | L | 3 |
| 15 | 2 | 13 | T | B | L | 4 | C | O | M | 3 | R | B | M | 2 | | | | |
| 16 | 2 | 14 | S | B | L | 1 | R | O | S | 2 | R | G | L | 3 | | | | |
| 17 | 5 | 24 | S | B | T | 2 | R | O | M | 4 | S | R | S | 3 | C | G | L | 4 |
| 18 | 3 | 29 | S | B | M | 2 | R | B | T | 1 | C | R | T | 4 | | | | |
| 19 | 1 | 5 | C | B | M | 2 | T | B | L | 2 | | | | | | | | |
| 20 | 4 | 8 | S | R | T | 1 | C | B | T | 2 | S | O | M | 3 | | | | |
| 21 | 5 | 22 | T | B | M | 1 | R | R | S | 2 | C | B | L | 3 | R | G | T | 2 |
| 22 | 3 | 30 | C | G | S | 1 | C | R | T | 2 | T | R | M | 4 | | | | |
| 23 | 1 | 1 | T | G | T | 1 | C | G | T | 2 | | | | | | | | |
| 24 | 4 | 12 | C | G | L | 2 | C | O | M | 1 | S | R | T | 2 | | | | |
| 25 | 2 | 15 | C | B | S | 3 | T | R | T | 2 | R | G | T | 3 | | | | |
| 26 | 1 | 4 | C | O | L | 1 | C | O | M | 2 | | | | | | | | |
| 27 | 4 | 9 | R | O | S | 4 | C | B | M | 4 | S | G | S | 2 | | | | |
| 28 | 2 | 16 | T | R | M | 2 | S | B | S | 1 | S | R | L | 3 | | | | |
| 29 | 5 | 20 | R | B | M | 2 | C | O | T | 4 | T | R | M | 1 | C | G | S | 3 |
| 30 | 3 | 28 | R | G | T | 2 | S | R | T | 4 | S | B | S | 3 | | | | |

# APPENDIX IV

## DIRECTIONS TO SUBJECTS

This is a task in remembering. You will see a sequence of two, three or four slides (show example slides) that vary as shown at the top of the response sheet.

Notice: The four sizes - large, medium, small and tiny. The narrow horizontal lines on the screen are the height of the small shapes. Shapes that are not as tall as these lines are tiny. The wide horizontal lines are the height of medium shapes. Larger shapes are large. The four colors - orange, green, black, red. The four shapes - circle, triangle, cross, square. The four numbers - one, two, three, four.

After viewing a sequence, you are asked to write a rule for that sequence — two values that occur more than once. (Show example). Some slides will show the complete rule, two values. Some will show half the rule, one value. All slides will show at least one-half the rule.

Do not make notes describing each slide; rather try to remember. You need to remember all the slides in a sequence to get the best rule. However, if you are not sure guess. There will be two, three or four slides in a sequence. I will tell you at the beginning of the sequence how many slides will appear in that sequence.

APPENDIX IV (Continued)

Let's look at some examples and I will explain how to use the answer sheet. (Show examples).

Since the rule is ______ and ______, write the rule on the response sheet (demonstrate*). If the answer is size or color, write the first two letters of the word; if shape or number, write the symbol (demonstrate). (Repeat with second example and demonstrate answers).

Now let's try some samples. This time you write the rule in the sample spaces with two letters for a size or a color and the symbol, shape or number when appropriate. (Show samples and review after each, pointing out the values and correct method to record the intended rule).

(Make the statement). I wish to avoid causing any embarrassment. However, to insure the data is accurate, will you indicate at the bottom of the page if you experienced any eye difficulty due to color blindness.

(*) A duplicate of the response sheet on acetate was projected on the viewing screen. The response for the example was written on the acetate to demonstrate the use of the response sheet.

## APPENDIX V

Name____________________

## R E S P O N S E   S H E E T

### VALUES

| | | | | | |
|---|---|---|---|---|---|
| SIZE | - | LArge | MEdium | SMall | TIny |
| COLOR | - | ORange | GReen | BLack | REd |
| SHAPE | - | ● | ▲ | ✚ | ■ |
| NUMBER | - | 1 | 2 | 3 | 4 |

Sample 1 ____ ____  Sample 2 ____ ____  Sample 3 ____ ____  Sample 4 ____ ____

Indicate the rule for each sequence - the two values which occur more than once.

| | | |
|---|---|---|
| Rule 1 ____ ____ | Rule 11 ____ ____ | Rule 21 ____ ____ |
| Rule 2 ____ ____ | Rule 12 ____ ____ | Rule 22 ____ ____ |
| Rule 3 ____ ____ | Rule 13 ____ ____ | Rule 23 ____ ____ |
| Rule 4 ____ ____ | Rule 14 ____ ____ | Rule 24 ____ ____ |
| Rule 5 ____ ____ | Rule 15 ____ ____ | Rule 25 ____ ____ |
| Rule 6 ____ ____ | Rule 16 ____ ____ | Rule 26 ____ ____ |
| Rule 7 ____ ____ | Rule 17 ____ ____ | Rule 27 ____ ____ |
| Rule 8 ____ ____ | Rule 18 ____ ____ | Rule 28 ____ ____ |
| Rule 9 ____ ____ | Rule 19 ____ ____ | Rule 29 ____ ____ |
| Rule 10 ____ ____ | Rule 20 ____ ____ | Rule 30 ____ ____ |

# APPENDIX VI

## EQUIPMENT AND MATERIAL

1. Projecting Equipment

   Transpaque Junior Model 6000

   Projection Optics Company, Inc.
   East Orange, New Jersey

2. Material used to produce slides:

| | Color | Code |
|---|---|---|
| 1. Diazochrome | Green | KGN |
| 2. " | Red | KRD |
| 3. " | Black | KBK |
| 4. " | Orange | KOR |

Technifax Corporation
195 Appleton Street
Holyoke, Massachusetts

3. Otis Quick-Scoring Mental Ability Tests: New Edition, Gamma Test: Form Em (30 minute); Harcourt, Brace and World, Inc., New York

4. Screen

   A wall-mounted 72" x 84" Matte
   Model "B"
   Da Lite Corporation
   Chicago, Illinois

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~~JUN 30 1966~~

~~JUL 14 1966~~

~~JUL 28 1966~~

~~1966~~

~~AUG 25 1966~~

~~SEP 8 1966~~