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THE RELATIONSHIP BETWEEN LEARNING CONCEPTS AND STUDENT ACHIEVEMENT.

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REPORT NUMBER CRP-S-493   PUB DATE 66
REPORT NUMBER BR-6-8037
EDRS PRICE MF-$0.18 HC-$4.56 114P.

DESCRIPTORS- LEARNING ACTIVITIES, *LEARNING LABORATORIES, LEARNING PROCESSES, *ACHIEVEMENT RATING, LABORATORY EXPERIMENTS, JUNIOR HIGH SCHOOLS, COMPARATIVE ANALYSIS, *CURRICULUM RESEARCH, *CONCEPT FORMATION, CONCEPT TEACHING, *MEASUREMENT TECHNIQUES, TERRE HAUTE, INDIANA

THIS RESEARCH CONCERNING CONCEPTUAL BEHAVIOR INVESTIGATED BOTH THE DEVELOPMENTAL ASPECTS OF CONCEPTUAL BEHAVIOR IN A CONTROLLED LABORATORY SITUATION AND THE RELATIONSHIP OF CONCEPT LEARNING IN THIS LABORATORY SETTING TO ACHIEVEMENT IN CURRICULAR AREAS OF JUNIOR HIGH SCHOOL. THE GENERAL PLAN FOR THIS STUDY INVOLVED STRATIFIED RANDOM SELECTION AND ASSIGNMENT OF 120 SUBJECTS INTO FACTORIAL, REPEATED MEASURES DESIGNS AND SUBSEQUENT USE OF THE DATA IN A FACTOR ANALYSIS STUDY. SCORES ON AN INFORMATION PROCESSING TEST, TIME-TO-CRITERION SCORES FOR CONCEPT ATTAINMENT PROBLEMS, AND ACHIEVEMENT TEST SCORES REPRESENTATIVE OF THE JUNIOR HIGH SCHOOL CURRICULUM WERE GATHERED FOR ANALYSIS. A RELATIONSHIP WAS FOUND BETWEEN MORE TRADITIONAL CONCEPT ATTAINMENT FACTORS AND CURRICULAR FACTORS, RESULTING IN THE CONCLUSION THAT THERE IS A HIGH RELATIONSHIP BETWEEN MODEL CONCEPT LEARNING AND THE CURRICULAR FACTORS GENERALLY. FINDINGS FROM THE FACTOR ANALYSIS LED TO THE CONCLUSION THAT SUCCESS IN CONCEPT ATTAINMENT TASKS IS RELATED TO SUCCESS IN CURRICULAR AREAS. (GD)

6-8037

S-493

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1966

The research herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education and Welfare.

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## CHAPTER I

## THE RELATIONSHIP BETWEEN LEARNING CONCEPTS AND STUDENT ACHIEVEMENT

### PROBLEM

The study of conceptual behavior in recent years has received much attention from empirical researchers. Such research has been concerned chiefly with (a) variables which affect concept attainment of adults or near-adults--specifically the college sophomore--or (b) developmental patterns of conceptual behavior in children. Representative of the first category is the work of Bruner et al. (1956), and of the second is the work of Inhelder and Piaget (1958). Researchers of the former category have come to use dimensionalized stimulus materials. Those of the latter seldom use these fabricated materials; rather children examining real materials which are relevant to functional concepts are observed. These differences have limited the application of research results from that group which uses dimensionalized materials to other groups concerned with educational practices involving children. If the void between these areas can be satisfactorily bridged, much knowledge which has previously been viewed as esoteric and basic in nature will have significance for classroom learning. It was toward this end that the present study was directed.

Two possible approaches to this general problem see[illegible] eadily apparent. The first is to structure knowledge into its various attributes and defining characteristics. The magnitude of the "stimulus material" here seems most formidable. The second is to introduce children at various age levels to tasks involving dimensionalized stimulus materials and then to examine the relationship of their performance on these tasks with more traditional curricular activities. This is the approach that was used in this study.

The basic problem was two-fold: (a) to investigate developmental aspects of concept acquisition involving dimensionalized stimulus material, and (b) to investigate the relationship of concept learning in this laboratory situation to achievement in selected curricular areas. To these ends, data were gathered and analyzed so as to answer the specific questions under consideration in this study:

1. What are the effects of the following variables upon information processing in concept attainment tasks: (a) grade level--seventh, eighth, and ninth; (b) sex; (c) exemplar or nonexemplar stimulus presentation; and (d) exemplar, nonexemplar, or indeterminant response options?
2. What are the effects of the following variables upon concept attainment: (a) grade level--seventh, eighth, and ninth; (b) sex; and (c) exemplar or nonexemplar stimulus presentation?
3. What are the common factors that account for the relationship among the concept attainment tasks and curricular achievement tests?

4. What are the relationships among laboratory variables and the curricular areas as determined by oblique relationships of the common (task and curricular) factors?

# CHAPTER II

## RELATED RESEARCH

### The Nature of Concepts

Concepts have been classified by Bruner, et al. (1956) as conjunctive, disjunctive or relational. A conjunctive concept is defined as the joint presence of one level each of two or more attributes. A disjunctive concept is defined as the presence of either one, another, or both levels of an attribute. Attribute here refers to a figural dimension of a stimulus display. A relational concept is defined by a specifiable relationship between levels of attributes. For example, cards with the same number of figures and borders exemplify a concept of a relational type.

Neisser and Weene (1962) describe 10 types of attribute arrangements which can be defined by the presence or absence of various levels of dimensions. Their's is an extension of Bruner's classification of concepts. It includes additionally: (a) negative instances of Bruner's three types, (b) either-or patterns, and (c) implication types. In further examination of types of concepts, Hunt (1961) found that conjunctive and relational solutions to concept attainment tasks using figural stimulus material were used by Ss more often than disjunctive types of solutions.

The general conclusion reached by those studying types of concepts is that the conjunctive type is the easiest and disjunctive is the most difficult for Ss to attain. The present research is concerned with the conjunctive types as defined by Bruner.

## Early Studies of Concept Attainment

Probably the best known of early studies of concept attainment and information processing in concept attainment are those conducted by Hull (1920), Heidbreder (1945), and Smoke (1932). Chinese characters were used by Hull (1920) as visual stimuli to form and test the formation of concepts by university students. Sequential presentation of 144 stimuli cards was accomplished with a memory drum. The Ss were exposed to a character for a period of five seconds and given the name of the associated concept by the experimenter. Perfect scores on two revolutions--24 exposures--of the drum were the criteria for formation of the concept. Frequency of correct responses was the criterion for testing the formation of the concepts. Certain specific results of Hull's experiment have been summarized by Harris and Schwahn (1961). These results have limited applicability to the present study; methodological factors are more relevant. For example, the sequential method of stimulus presentation in the study became almost a tradition up to the 1950's when Bruner et al. (1956) conducted their work using simultaneous presentation methods. In their work simultaneous presentations of stimulus materials were made; and additionally, conceptual membership of the stimulus cards was specified upon S's selection of instances to be tested. The use of visually presented stimulus materials by Hull which are unique to experimental Ss is also a relevant methodological factor used in the present study.

Heidbreder (1945), (1946), (1948), (1949) also using serial presentation, conducted a series of studies on concept attainment with pictorial stimulus presentation. Her contributions to this area of study include the adaptions of terminology and the application of methodology to concept attainment. She was also especially concerned with stimulus variables: (a) familiarity, (b) simplicity, (c) uniformity of visual patterns, and (d) goodness of form. One of her interesting findings regarding stimuli was that a hierarchy existed among concrete objects, spatial forms and numbers with number the most difficult. Though her conclusions are not particularly relevant to the present study, they are of historical significance indicating: (a) continuing interest in concept attainment, and (b) attempts at the classification of variables related to concept attainment.

In an early article Smoke (1932) reported that negative instances did little to facilitate concept attainment. Subsequently, Smoke (1933) reported no statistically significant difference in efficiency of concept learning between all positive or positive and negative instances on a task in which Ss attained concepts embedded in geometrical designs. Time-to-criterion scores were used as the dependent variable. These studies are some of the earliest research in which reference to exemplar (positive) and nonexemplar (negative) instances is made.

Information Processing in Concept Attainment

The most complete treatment of information processing to date has been presented by Hunt (1962). Not only does his book summarize work done in this area, but it also articulates an information processing plan for the attainment of concepts. Such plans don't require a S to be cognizant of an hypothesis regarding the relevant attributes of a concept. Rather, through information processing, it is possible to check the relevance of each dimension successively. Thus information processing, may be distinct from other attainment procedures.

Hovland (1952), examining more closely the fact that concept attainment could be studied in terms of information processing, presented a theoretical analysis of the type of multi-level, dimensionalized stimulus material similar to that used in the present study. He demonstrated that the relative number of exemplars and nonexemplars varies as a function of: (a) the total number of dimensions involved, (b) the number of dimensions relevant to a concept, (c) the total number of values used for each dimension, and (d) the number of relevant values of each dimension. An independent analysis by Harris (1963) concurred with and extended Hovland's analysis.

Hovland (1952) also discussed the theoretical amounts of information potentially conveyed by positive and negative instances of a concept and concluded that in a restricted situation each potentially yields an equal amount of information. A study by Buss (1950) was cited as suggesting the correctness of this conclusion in Hovland's article. Examination of this study failed to show evidence of equality of exemplars and nonexemplars *per se*. Buss concluded only that a concept could be learned with positive and negative instances in a learning series.

Hovland and Weiss (1953) subsequently examined the effects of positive and negative instances on information transmission. Sequential presentation of figural stimulus material was made to *Ss*. *S*'s task was to derive the combination of characteristics defining the concept. Results of the study indicated that positive instances conveyed information best, mixed positive and negative instances simultaneously presented conveyed information at an intermediate level, and all negative instances were consistently inferior to the previous two. While Hovland and Weiss disproved the notion that concepts cannot be learned from all negative instances, no experimental evidence was presented indicating that nonexemplars potentially convey amounts of information equal to comparable exemplars.

Tagatz and Meinke (1966) also examining positive and negative instances found no significant differences between the information yield of exemplars and nonexemplars when the information yield was examined independently of a total concept. This gave empirical support to the theoretical formulations of Hovland (1952) and Harris (1963). However, Hovland's (1952) analysis of exemplars and nonexemplars failed to consider that inter-card relationships can be a source of information in concept attainment tasks, as Tagatz (1963) has shown. The present study was designed to investigate this information processing variable more completely as well as its relationship to concept attainment as a whole and other curricular areas.

Variables Influencing Concept Attainment

In the first Technical Report of the Research and Development Center for Learning and Re-education at the University of Wisconsin, Klausmeier et al. (1965) presented a Taxonomy of Variables in Concept Learning. Major categories involved included stimulus variables, instructional variables, response variables, organismic variables, and other conditions influencing conceptual learning.

The concept attainment problems involved in the present study were selected in an attempt to more completely understand certain stimulus variables and to appraise differences among organismic variables. Certain other factors considered in the Taxonomy resulted in the specific experimental procedures that were employed. The following review of research relative to variables influencing concept attainment considers studies related to both of these conditions, and other factors that helped determine the experimental procedures used. Three subsections follow:

First, relevant stimulus variables will be considered. Next, consideration of organismic characteristics will be examined; and lastly, material related to other variables which helped to delineate the procedures of the experiment will be considered.

Stimulus Variables. The effects of intermittent reinforcement of an irrelevant dimension and task complexity upon concept attainment was studied by Bourne and Haygood (1959). Their task also required Ss to categorize visually presented stimuli. A repeated measures factorial design included six levels of intermittent reinforcement (50%, 60%. . . 100%) and three levels of task complexity (1, 3, and 5 irrelevant stimulus dimensions in addition to the intermittently reinforced dimensions.) During initial learning the intermittent reinforcement facilitated concept attainment. However, it had an inhibiting effect on transfer problems in which the irrelevant dimensions became relevant.

Regarding stimulus complexity, they concluded that increasing the number of irrelevant stimulus dimensions tends to decrease efficiency. In a supplementary report, Bourne and Haygood (1961), using experimental procedures similar to their previous study, found that relevant redundancy of stimulus dimensions facilitates S's performance on concept identification problems. Color and shape were redundant dimensions in their experiment.

Archer, Bourne, and Brown (1955) studied the effect of the addition of irrelevant dimensions to a sorting task in which cards were assigned to appropriate categories based on figural dimensions. An oscilloscope was used as the presentation method. Findings indicate that efficiency of performance decreases as the number of irrelevant stimulus dimensions increases.

Archer (1962) found that there was an interaction between obviousness and relevance of stimulus material so that S's performance was facilitated on a task of categorizing visually presented stimuli. Archer concluded that the optimum condition for Ss to identify a concept is when the obviousness of the relevant information is maximized and the obviousness of irrelevant information is minimized. Another interesting finding was that men found the task easier when form was relevant rather than irrelevant, and the opposite was true for women. Archer concluded that the difference was not likely biological, but rather it might have been the difference in availability of distinctive labels by the two sexes for the various forms.

Organismic Variables. With the exception of certain obvious physical variables, organismic characteristics have received little attention from the experimental researcher. In the Taxonomy mentioned previously, five major categories of organismic characteristics were articulated; namely, cognitive, psycho-motor, affective, physical and socio-cultural. A quick examination of the concept-learning bibliography in the same technical report found few articles reporting empirical findings relative to any of these five characteristics. It appears that this is an avenue of research that has been neglected. In discussing this particular problem, Bourne (1966) concluded that research in the area is sparse, primitive, and unsystematic.

Two approaches to the research of this area are readily apparent. The first is the stratification on the basis of the organismic characteristics and second is the attempted manipulation of the situation so as to either identify or produce organismic change.

Flizak (1963) reported a study of the relationship of age and efficiency of attaining concepts. Two groups of Ss were compared. The mean age for the younger Ss was 21.2 years with a range from 20-25 years. The mean age for the older Ss was 29.4, and the age range we~ 25-30 years. In a second experiment a young and an old group was again identified with a mean difference of ten years between the two groups. Younger Ss averaged 21.7 years; older Ss averaged 31.7 years. Time-to-criterion scores on six and four concept attainment problems, respectively, were the dependent variable. Results of both experiments indicated that young Ss are more efficient in the process of attaining concepts.

Le^ke (1963) examined the relationship among divergent and conv - gent thinking abilities and concept attainment. Ss for his study consisted of 40 males and 40 females in a younger group and 40 males and 40 females in an older group. The number of statistically significant relationships and the absence of significant correlations for either younger or older Ss lead to the conclusion that concept attainment is not associated with the organismic variables considered in that study, namely, logical reasoning, grade point average, ideational fluency, and spontaneous flexibility.

Tagatz (1963) examining the effect of selected variables on both information processing in concept attainment and concept attainment as a whole, included in his analyses the effect of sex difference. Ss were 72 students, stratified on the basis of sex with equal numbers of males and females, enrolled in Educational Psychology. The information processing activities were similar to those used in the present study as were the concept attainment problems. There were no significant differences in either analyses between male and female Ss.

Memory, also viewed by Bourne (1966) as an organismic variable, has been researched by Cahill and Hovland (1960). Two types of serial presentations were studied. In one presentation method, instances were removed prior to presentation of the next in the series; under the second, all instances remained in view. Memory effects were studied by comparing the number of cases where guesses as to the concept were incompatible with information presented in prior instances under the two conditions. Ss who made more "perceptual-inference" and "memory" errors had greater difficulty in acquiring concepts.

Hunt (1961) presented Ss with a series of figural instances sufficient to determine a concept after having first been presented with a series which presented labelled instances, the labelling indicating positive or negative membership to the concept which was to be attained. An interference effect was found for instances intervening between the information transmitting instance and the beginning of the test; i.e., a linear relationship was found between the first series of presentation and the second.

Memory is thus shown to have an effect on performance in concept attainment tasks. The present study was designed to minimize this source of variance by indicating the membership of a sufficient number of instances to attain the concept and not requiring Ss to select instances as has been required by certain other researchers, e.g. Bruner et al. (1956).

Other Relevant Variables. Callantine and Warren (1955) conducted an experiment to compare concept formation under single and multiple training problem conditions. The stimulus material consisted of 3 x 3 inch cards containing two geometric figures. A card sorting procedure was used in which six groups of 20 Ss each sorted cards into four conceptual categories. The four concepts were: (a) both color and form the same, (b) color different but form the same, (c) color the same but form different, and (d) both color and form different. The six groups were defined with respect to the training they received. For example, one group received four different stimulus patterns per concept, each repeated five times; another group received one pattern, repeated 20 times. Results indicated that in some learning situations, human learning is facilitated by training on a variety of problems of the same type.

Oseas and Underwood (1952) studied the attainment of concepts embedded in trichotomous levels of three figural dimensions. S's responses to sequentially presented stimuli consisted of alphabetic letters. The independent variable studied was time between problems. Massed practice (six second intervals between problems) resulted in less efficiency than did distributed practice (treatment conditions of 15, 30, and 60 seconds between problems) in conceptual categorization. The fact that no significant difference existed between the 15, 30, and 60 second treatments is relevant to the procedures used in the test constructed for this study. Ss were given a 15 second interval to solve information processing problems with no less than 15 seconds between problems.

The Relationship of Concept Attainment and Curricular Areas.

Fewer studies of the relationship between concept attainment and learning in curricular areas are evident in the literature than one would expect when considering the potential significance of such research. Studies reported in the following section will present the results of studies regarding the relationship of concept attainment to the language arts curriculum, the mathematics curriculum, and the science curriculum.

Language Arts. Braun (1963) reported a study designed to examine the relationship between concept formation ability and reading achievement of boys in the third, fifth, and seventh grades. She hypothesized that there would be a positive relationship between concept formation ability and reading achievement. She also hypothesized that the magnitude of the relationship between concept formation and reading is greater than that between reading and intelligence. The concept attainment task consisted of 20 concepts with six cards presented per concept. There were four words typed in a horizontal line on each of the 3 x 5 cards, and each of the cards contained one word that had something in common with one of the words on each of the other cards. A S typically was shown each card and had it read to him. Following this a S was asked to tell what the concept was that appeared on every card. If it was necessary, the cards were read to the S a second time. The two hypotheses were both supported, namely: (a) there was a positive relationship between concept formation ability and subsequent reading achievement, and (b) the magnitude of the relationship between the concept formation and the reading was higher than between reading and intelligence.

Bloomer (1961) examining concepts of meaning and the reading and spelling difficulty of words, concluded that the teaching of reading would be more effective if greater emphasis would be placed upon words which have specific and concrete meanings. He also concluded that greater emphasis in making these words meaningful to children would have significant effects on reading achievement. Concreteness was represented by the degree of direct contact with the senses. This was contrasted with terms which were represented by definition through use of other words.

Mathematics. Elkind (1961) in a study replicating Piaget's studies of the development of quantitative thinking, used 80 school and pre-school children who were divided into three age groups, namely, four, five, and six/seven-year-olds. These youngsters were tested on three types of materials, namely: manipulation of sticks, liquids and beads. They were also tested on three types of quantity measures, namely: gross quantities (which are defined as single perceived relations between objects, i.e., larger than, longer than). A second and more complex type of quantity is intensive quantity. These are perceived quantity relations taken two by two: longer and wider, taller and thicker. The third is called an extensive quantity. Extensive quantities are unit relations between objects: X is half of Y, X is twice Y, etc. The analysis of variance showed that success in comparing quantities varied significantly with age, type of quantity, and type of material. The correlations for types of materials were positive, high, and significant, thus supporting Piaget's assumption that a common conceptualizing ability underlies children's success in comparing quantities with different materials. The correlation of scores on the tasks previously described and WISC scores were positive, generally low, and only sometimes significant. This suggests that the ability to conceptualize, or concept attainment ability as it might be called, is only partially dependent upon intelligence.

Freyburg (1966) studied the relationship between general intellectual ability, conceptual development, and attainment in arithmetical computation and arithmetical problem solving and spelling. One hundred and fifty-one children, whose ages ranged from six to nine years were the Ss for the study. A 72 item, objective test of concept development was used. Items included tests of conservation of quantity and weight, of numerical correspondents, of additive composition of numbers in classes, and of concepts of position in space, speed, kinship and causal relationships. Higher correlations were found between mental age and concept attainment than between concept attainment and chronological age. The author also stated that mental age and conceptual development scores showed only a moderate degree of association. Freyburg concluded that children's school performance associated with aspects of conceptual development is not adequately assessed by conventional intelligence tests.

Feigenbaum (1963) conducted an experiment to test whether Piaget's explanation emphasizing logical operations occurring in a variable stage system is sufficient to account for success or failure in understanding the principle of conservation. Several tests of correspondence and conservation were used. For example, the Ss in one treatment were presented with 20 beads all of the same dimension. They were instructed to drop simultaneously one bead into one glass and another bead into a second glass of the same dimension. After putting all of the beads into the two glasses, Ss were asked the following questions: "What glass has more beads in it?" "Do the two glasses have the same number of beads?" "Can you tell me why?" Thus, correspondence was measured. In a test of conservation E took the beads that the S had put into one of the glasses of equal size and poured them into glasses of smaller dimensions, causing the level of the beads in the smaller glass to appear higher than the level in the other glass. The Ss were then asked the following questions: "Which has more beads in it?" "Or do the two glasses both have the same number of beads?" "Can you tell me why?" In this way conservation was tested. Ss for this study were 90 students from nursery and elementary schools. Their ages ranged between four and seven which was similar to Piaget's original group. Feigenbaum concluded that the acquisition of the conservation concept was not defined by definite ages or stages, rather Ss' ability to solve the tasks used in the study were suggestive of a gradual development. The data also indicated that the children's grasp of the conservation concept tended to vary with their IQ and with the nature of concrete experimental operation.

Science. The last curricular area to be considered is the science curriculum. The studies considered here pertain to Ss' attainment of concepts related to science.

Nelson (1958)(1960) reported that children from grades four, five and six can achieve significant gains in their understanding of concepts and principles related to light and sound when they are given instruction. There were no significant differences in improvement, however, associated with the grade level of the pupils nor the sex of the Ss.

King (1960) studied children's responses to seventy questions related to science concepts. The questions were organized around five headings: a) concepts of length, weight, time, and direction, b) concepts of mechanics, levers, and wheels, c) concepts of living things and seasons, d) concepts of volume and weight, and e) concepts of shadows and sections. Working with 1,811 children whose ages ranged from five to twelve years, King found a gradual development of the reasoning abilities of children. This finding of a gradual development of the reasoning processes was interpreted by the author as nonsupportive evidence of Piaget's stages of development.

Atkin (1961) selected brighter than average children, IQ scores over 105, in grades four, five and six. They were given twenty-five sessions of fourty-five minutes each. The content of the material presented to the Ss was related to concepts and principles of astronomy. He found that the Ss were interested in the sessions of astronomy, that the Ss were able to conceptualize many of the topics that were presented, and that boys participated in classroom discussions more freely than girls.

In a later study, King (1963) used only twenty questions related to science concepts. His Ss were 368 boys and 433 girls who ranged in age from 5 years and 4 months to 17 years, 3 months. He found the rate of growth of scientific knowledge of boys and girls to be similar at the primary school level. Knowledge of science concepts, however, was significantly greater for boys at the secondary school level.

Four concept attainment problems were given to high school sophomores by Olson (1963). Two problems were related to science. One was concerned with reciprocating motion, and the other with levers. Olson found no sex differences for three of the concept problems, but boys scored significantly higher than girls on the lever concept problem. Furthermore, there were no significant differences in concept attainment when only positive instances were presented compared with both positive and negative instances presented together.

It would seem from these studies concerned with children's acquisition of science concepts that boys and girls do equally well in the primary grades. Boys may, however, do better with certain concepts at the secondary level. Rather than pointing to a physiological difference to account for these findings, it would appear more tenable to hypothesize that boys may develop differential interests compared to girls or that they develop better verbal referents to handle some scientific concepts. The failure to support Piaget's stages of development related to reasoning might be attributed to King's cross-sectional approach rather than the study of one individual intensively over time.

Summary

In this review of related research the nature of concepts and some early studies of concept attainment have been examined. Studies of information processing in concept attainment have been reviewed. Then selected variables influencing concept attainment en todo which are related to variables under consideration in the present study were examined. Finally studies concerning the relationship of concept attainment to curricular areas have been reviewed.

The type of concepts used in the present study are conjunctive in nature as defined by Bruner et al. (1956). Research dealing with types of concepts indicates that the conjunctive type is the easiest for Ss to attain, disjunctive the most difficult, and relational intermediate in difficulty. The present research is concerned with the conjunctive type which appears to be most common in human use.

Concerning information processing in concept attainment, Hovland (1952) appears to have presented the first complete analysis. He demonstrated that the theoretical amount of information potentially conveyed by positive and negative instances was equal in restricted situations. This was empirically validated by Tagatz and Meinke (1966) for information processing tasks, but these information processing tasks were somewhat dissimilar from certain other concept attainment tasks

The present study was designed to ascertain the relationship of both of these types of tasks and curricular achievement.

Variables influencing concept attainment examined in this section concerned stimulus variables, organismic variables, and other variables concerning procedures. Regarding stimulus variables, several generalizations seem established: (a) Increasing the amount of irrelevant information decreases efficiency of concept attainment. (b) Redundancy of relevant dimensions facilitates S's performance. (c) The optimum condition for Ss to identify concepts is when the most obvious dimensions are relevant and when the more obscure dimensions are irrelevant to a concept to be attained.

It was concluded that the present understanding of organismic variables is limited. Sex differences involving older Ss were not evident. Memory, also viewed by Bourne (1966) as an organismic variable, was found to be significantly related to concept attainment where Ss selected and were required to retain information through card selection activities.

Methodological variables were also examined. Here, too, some conclusions seem established: (a) Performance decreases as delay in feedback increases. (b) Increasing the amount of incorrect feedback decreases efficiency. (c) In some learning situations, human learning is facilitated by multiple problem training. The present study controls feedback in that feedback occurs during problems following each concept offered by the S.

Finally, studies concerned with the relationship of concept attainment and curricular areas were considered. The curricula areas were language arts, mathematics, and science. These studies reveal specific and general findings.

Specific conclusions found were: a) Concept formation ability is related to reading achievement to even a greater extent than reading achievement is related to I. Q. b) In teaching reading the recommendation was made that emphasis should be placed upon words with specific and concrete meaning. c) One study supports Piaget's assumption that some common conceptual ability underlies the child's success with the comparison of quantities of differential matter.

There seems to be emerging some consistent general findings that run across the curricular areas: a) Tests of intelligence now in use do not assess the child's school performance associated with conceptual development. b) Boys and girls seem to develop competency with concepts at about the same rate during the primary school years. When sex differences are found, they generally appear at the secondary school level and relate to specific concept problems. c) Piaget's stage theory of reasoning ability was not generally supported, but, rather, there seemed to be a gradual or general developmental trend in children's reasoning ability associated with concept acquisition.

# CHAPTER III

## PROCEDURES AND EXPERIMENTAL DESIGN

### Subjects

Subjects (Ss) for the study were 20 males and 20 females each from three grade levels--seven, eight, and nine. Thus, a total of 120 Ss participated. The stratified sample was selected from a total of 207 Ss enrolled in Junior High School at the Campus Laboratory School at Indiana State University.

This pool of Ss represents a wide range of ability levels. The average IQ for the students studied was 105, with a range from 71-145. The area in which many of these students live is presently the object of urban renewal plans. Hence, the low end of the socio-economic continuum is represented. Additionally, approximately 15 percent of the school's enrollment consists of children of professional people. Thus, the extremes of the socio-economic continuum are well represented. Normal promotional policies are practiced within the school and, as a result, typical age increments exist among the grades used. In summary, the students used were representative of a wide range of social and economic factors and intellectual abilities. Hence, they were considered excellent Ss for this study.

### Experimental Materials

Stimulus materials for concept attainment tasks traditionally possess characteristics by which similarities and differences between instances can be observed. In this way, universes are fabricated by experimenters. Fabricated universes have the advantage of being manipulated readily. The present study makes use of this advantage.[1]

The information processing tasks and the concept attainment problems in this study used as their material base an array of 64 stimulus cards. Six attributes were represented on each card by one of two defining characteristics. These six attributes and their defining characteristics were:

1. Border Number: One or Two
2. Border Type: Solid or Broken
3. Figure Number: One or Two
4. Figure Size: Large or Small
5. Figure Color: Red or Green
6. Figure Shape: Circle or Ellipse

Each card was different from all other cards on that display in at least one of the dichotomous defining characteristics. Each defining characteristic appeared on 32 cards; its pair appeared on the remaining 32 cards.

This stimulus construction permitted the categorization of cards on the basis of dimensions. Regarding the categorization process, Bruner, _et al._ (1956) stated: "To categorize is to render discriminably different things equivalent, to group the objects and events and people around us into classes, and to respond to them in terms of their class

[1]The reader's attention is directed to Hovland (1952) and Harris (1963) and Tagatz (1963) for more detailed discussions of this type of stimulus construction.

membership rather than their uniqueness." The cards on the display were discriminably different in one or more defining characteristics; they were minimally similar in that they were all members of the same universe, i.e., they all contained the six dimensions. Most cards shared one or more identical defining characteristics. In this way they could be equivalent.

Information Processing Data. For the information processing tasks, slides were used showing various cards from the stimulus board described above. Directions (see Appendix I) were also prepared for the purpose of instructing Ss about information processing.

Sixty slides constituted the information processing test. Two additional slides were presented for instructional purposes prior to the presentation of each half of the test. The first half consisted of items in which one card, either an exemplar or nonexemplar, was presented in addition to an exemplar focus card. Ss' task was to specify the inclusion, exclusion, or indeterminance of still another card to membership in a group of cards exemplifying a concept. Problems presenting exemplars numbered 15; those presenting nonexemplars numbered 15. In these 15 exemplar items, 10 test cards, i.e., the cards for which membership was to be determined, were definitely exemplars of the same concepts that the focus card exemplified. The membership of the remaining five test cards could not be determined. In the 15 problems presenting a focus card and a nonexemplar, 10 test cards were definitely nonexemplars and five were again not determinable. Thus, these 30 problems could be scored on the basis of information presented--15 exemplars and 15 nonexemplars--or it could be scored on the basis of test card membership--exemplar, nonexemplar, and cards of indeterminant membership.

(See Fig. 1.) These three conditions of membership for test cards constituted the response options available to Ss.

| Stimulus Presentation | Subtest One | Subtest Two | Response Options |
|---|---|---|---|
| Exemplars | 1 | 31 | Inclusion |
| | 2 | 32 | |
| | 3 | 33 | |
| | 4 | 34 | |
| | 5 | 35 | |
| | 6 | 36 | |
| | 7 | 37 | |
| | 8 | 38 | |
| | 9 | 39 | |
| | 10 | 40 | |
| | 11 | 41 | Indeterminance |
| | 12 | 42 | |
| | 13 | 43 | |
| | 14 | 44 | |
| | 15 | 45 | |
| Nonexemplars | 16 | 46 | |
| | 17 | 47 | |
| | 18 | 48 | |
| | 19 | 49 | |
| | 20 | 50 | |
| | 21 | 51 | Exclusion |
| | 22 | 52 | |
| | 23 | 53 | |
| | 24 | 54 | |
| | 25 | 55 | |
| | 26 | 56 | |
| | 27 | 57 | |
| | 28 | 58 | |
| | 29 | 59 | |
| | 30 | 60 | |

Fig. 1. Information processing tasks showing stimulus presentation and corresponding response option for Subtest One and Subtest Two. The order of presentation of items within subtests was random.

The second 30 items were constructed using the same focus cards and test cards as the first 30. The information presented in addition to the exemplar focus card consisted of two cards rather than one as in the first subtest. One of the two cards for each problem was an additional exemplar; the other was the same in kind as its counterpart in the first 30 items. The answers to the 30 items of Subtest Two were exactly the same except that the information presented about the test card in the second subtest included the additional complexity of one card.

Concept Attainment Tasks. For the concept attainment problems the 64 card stimulus display was used. Directions were prepared for instruction of Ss as to the procedures of concept attainment. (See Appendix II.) Markers specifying exemplars, nonexemplars and an exemplar focus card were used to specify the membership of cards to the conceptual category for the respective problems. A stop watch was used as a timing device. Figure 2 is a replication of the answer sheet on which S responded with

| | | | | | |
|---|---|---|---|---|---|
| 1. | Border Number | One | ( ) | Two | ( ) |
| 2. | Border Type | Solid | ( ) | Broken | ( ) |
| 3. | Figure Number | One | ( ) | Two | ( ) |
| 4. | Figure Size | Large | ( ) | Small | ( ) |
| 5. | Figure Color | Red | ( ) | Green | ( ) |
| 6. | Figure Shape | Circle | ( ) | Ellipse | ( ) |

Fig. 2. Answer sheet on which Ss marked their responses to the concept attainment tasks.

his concept. This was done by checking the relevant defining characteristics of the various attributes. Summary sheets on which complete data for each problem were recorded were prepared for all individuals. (See Appendix III.)

The problems or concepts to be attained were "solid border with one-red figure" and "broken borders with small-elliptical figures." Each of these concepts was used twice. The concept was presented through exemplar instances in the first situation and through an exemplar focus card and nonexemplar instances in the second situation. Figure 3 indicates a verbal description of the defining characteristics of each attribute of the cards specified as illustrating or not illustrating the concept.

Achievement Test Data. Prior to data collection, four factors had been hypothesized from curricular areas as potentially being related to information processing and/or concept attainment. These factors were: numerical, verbal, social studies, and science. Tests from four standardized achievement batteries were used as data gathering instruments. These were: (a) California Achievement Tests, Form W; (b) SRA Achievement Series, Form A; (c) Stanford Achievement Tests, Form W; and (d) selected tests from the Sequential Tests of Educational Progress. Figure 4 indicates the hypothesized relationship of these tests to the factors. A total of 30 achievement tests and/or subtests were administered.

Experimental Procedures

Data of three types were gathered for subsequent analysis in the study. These were: (a) scores on the information processing test, (b) time-to-criterion scores for the concept attainment problems, and (c) achievement test scores representative of the curriculum of the

CONCEPT I

Broken Borders with Small Elliptical Figures

Exemplar Presentation

| FOCUS CARD | FIRST EXEMPLAR |
|---|---|
| Two Borders | Two Borders |
| Broken Borders | Broken Borders |
| Two Figures | Two Figures |
| Small Figures | Green Figures |
| Red Figures | Small Figures |
| Ellip. Figures | Ellip. Figures |

| SECOND EXEMPLAR | THIRD EXEMPLAR |
|---|---|
| Two Borders | One Border |
| Broken Borders | Broken Border |
| One Figure | Two Figures |
| Red Figure | Red Figures |
| Small Figure | Small Figures |
| Ellip. Figure | Ellip. Figures |

Nonexemplar Presentation

| FOCUS CARD | FIRST NONEXEMPLAR |
|---|---|
| Two Borders | Two Borders |
| Broken Borders | Broken Borders |
| Two Figures | Two Figures |
| Small Figures | Red Figures |
| Red Figures | Small Figures |
| Ellip. Figures | Circular Figures |

| SECOND NONEXEM. | THIRD NONEXEMPLAR |
|---|---|
| Two Borders | Two Borders |
| Solid Borders | Broken Borders |
| Two Figures | Two Figures |
| Red Figures | Red Figures |
| Small Figures | Large Figures |
| Ellip. Figures | Ellip. Figures |

CONCEPT II

Solid Borders with One Red Figure

Exemplar Presentation

| FOCUS CARD | FIRST EXEMPLAR |
|---|---|
| Two Borders | One Border |
| Solid Borders | Solid Border |
| One Figure | One Figure |
| Large Figure | Red Figure |
| Red Figure | Large Figure |
| Circular Figure | Circular Figure |

| SECOND EXEMPLAR | THIRD EXEMPLAR |
|---|---|
| Two Borders | Two Borders |
| Solid Borders | Solid Borders |
| One Figure | One Figure |
| Red Figure | Red Figure |
| Large Figure | Small Figure |
| Ellip. Figure | Circular Figure |

Nonexemplar Presentation

| FOCUS CARD | FIRST NONEXEMPLAR |
|---|---|
| Two Borders | Two Borders |
| Solid Borders | Broken Borders |
| One Figure | One Figure |
| Large Figure | Red Figure |
| Red Figure | Large Figure |
| Circular Figure | Circular Figure |

| SECOND NONEXEM. | THIRD NONEXEMPLAR |
|---|---|
| Two Borders | Two Borders |
| Solid Borders | Solid Borders |
| One Figure | Two Figures |
| Green Figure | Red Figures |
| Large Figure | Large Figures |
| Circular Figure | Circular Figures |

Fig. 3. Verbal description of the defining characteristics of each attribute for cards which exemplified or did not exemplify the two concepts presented through exemplar focus cards and either exemplar or nonexemplar instances.

| I. Number | II. Verbal | III. Social Studies |
|---|---|---|
| SRA - Arith. Reas. | A. Vocabulary | Stanf. - Soc. Stu. |
| SRA - Arith. Comp. | | SRA - Charts |
| Stanf. - Arith. Comp. | Calif. - Read. Vocab. | SRA - References |
| Stanf. - Arith. Appli. | SRA - Read. Vocab. | STEP - Soc. Stu. I |
| Calif. - Arith. Reas. | | STEP - Soc. Stu. II |
| STEP - Math II | B. Spelling | |
| | Stanf. - Spelling | IV. Science |
| | Calif. - Spelling | |
| | SRA - Lang. Arts | Stanf. - Science |
| | | STEP - Science I |
| | C. Reading Comprehension | STEP - Science II |
| | Stanf. - Para. Mean. | |
| | Calif. - Read. Comp. | |
| | SRA - Read. Comp. | |
| | D. Grammar | |
| | Stanf. - Lang. | |
| | Calif. - Mech. of Eng. | |
| | SRA - Lang. Arts I | |
| | SRA - Lang. Arts II | |

Fig. 4. Hypothesized relationships of tests to four achievement factors.

junior high school within which conceptual behavior is evident. Description of the procedures followed in gathering these three types of data follow.

Information Processing Data. The E went into the classroom to test the Ss in information processing. A screen and lantern slide projector were set up beforehand. There were approximately 30 Ss in each classroom who were tested as a group. The classroom teacher remained in the room during the testing.

Directions with attached answer sheets and pencils were passed out to each S. The E read the directions aloud while the Ss read along silently. (see Appendix I.) The 64 card stimulus display board, as described previously, was used to depict the six properties or characteristics of each card. It was placed prominently in view and referred to when appropriate. An example of the first task to be solved by the Ss was presented on the screen and explained to them. There were three cards in this example: (Figural characteristics of each card are semantically presented in this report.)

| Focus Card | | Yes Card | | Test Card | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | One | Border Number: | One |
| Border Type: | Broken | Border Type: | Broken | Border Type: | Broken |
| Figure Number: | Two | Figure Number: | One | Figure Number: | One |
| Figure Color: | Green | Figure Color: | Red | Figure Color: | Green |
| Figure Size: | Large | Figure Size: | Large | Figure Size: | Small |
| Figure Shape: | Elliptical | Figure Shape: | Circular | Figure Shape: | Circular |

The Ss were to determine if the test card was: (a) a "yes" card (an example of the concept), (b) a "no" card (not an example of the concept), or (c) a "can't tell" card (not enough information presented to determine the card's membership). Thirty problems each containing three cards--a focus card, either a yes card or a no card, and a test card--were to be solved by the Ss. They were to fill in their answers ("yes," "no," or "can't tell") on an IBM answer sheet for these 30 problems. There was a 15 second interval between the presentation of each slide.

Directions for the second task to be solved by the Ss were then read aloud to them. An example of this type of problem was presented on the screen and explained. The second task was similar to the first except that four cards rather than three were used. In this way, more information was presented to the _Ss_. Each problem in this group used the same focus card and test card as in the respective item in the first half of the test. A 15-second interval was again used between the presentation of each slide, and again 30 slides were presented to the _Ss_. The _Ss_ answered either: (a) "yes," (b) "no," or (c) "can't tell" to these 30 problems, also on an IBM answer sheet.

Upon the completion of the two parts of this information processing test, the instructional booklet and the answer sheets were collected from each _S_. At this time, they were asked not to divulge the nature of the activity to members of other classes in the school. They were also informed that they would be participating in additional activities, and as a result their cooperation was requested.

Concept Attainment Data. The _E_ picked up each _S_ at his classroom and took him to the room in which all of the concept attainment data were collected. This room was about the size of a classroom and contained two desks and a large rectangular table. The 64 card stimulus display, as described previously, was laid upon one end of the table. Directions for these concept attainment problems (see Appendix II) were placed just below the edge of the stimulus display in front of the _Ss_. _E_ sat across from _S_. Again, directions were read aloud to the _S_ as he read them silently. These directions presented a review of the characteristics of the stimulus display and the meaning of "conceptual categorization." _S_ was shown how to respond with the concept when he thought he knew it by using a special form illustrated previously in Fig. 2.

Each S was then required to solve four problems. These four problems consisted of two concepts; each presented through exemplar and nonexemplar instances. These four problems could be examined on the basis of: (a) exemplar presentation and nonexemplar presentation; (b) problem (concept) one or problem (concept) two; or (c) the interaction of problem by exemplar-nonexemplar.

An exemplar focus card, along with the three additional exemplars or three additional nonexemplars was presented for each problem. Each card varied one dimension from the exemplar focus card. Thus the dimensions of the concept were delineated through either (a) the one dimensional difference of each nonexemplar or (b) the commonality of dimensions of the three exemplars and the focus card. All of the presentations of these four problems were random. Markers were arranged specifying the exemplar focus card and other exemplars or nonexemplars. Timing was begun upon placement of the last marker. When S offered an hypothesis for a concept, he checked the relevant characteristics on the slip which was provided for him. (see Fig. 2.) E read the concept back to him. If he was correct, E said "correct" and the problem was over. If he was not correct, E said "not correct; continue" and S again attempted to determine the concept. Upon the completion of each problem, time-to-criterion was recorded. If a S failed to solve a problem within a 15-minute time interval, E terminated that problem by indicating the relevant characteristics of the concept and articulated how the concept might have been attained from the information presented. The session was terminated and S returned to his classroom when all four problems had been completed. He was asked again not to divulge the nature of the task.

Achievement Test Data. Achievement tests were administered intermittently throughout the second semester. Seventh and eighth grade Ss were tested as one group; ninth grade was another group. Both groups typically were given the same subtests on the same day.

The room used for testing was a ballroom of the Tirey Memorial Union building at Indiana State University. The room was equipped with a public address system for the presentation of directions and was adequately lighted and ventilated. Tables provided ample working space for Ss. Ss were accompanied to the testing room from the Laboratory School of Indiana State University by their teacher. The teacher remained until after testing was underway.

The publisher's directions for administration were followed for all tests. Tests from the following achievement batteries were administered: (a) California Achievement Test, Form W; (b) SRA Achievement Series, Form A; (c) Stanford Achievement Test, Form W; (d) Sequential Tests of Educational Progress, Form A. After the administration of tests from the respective batteries, an interval of from one to three weeks was allowed. During this time no achievement testing was undertaken.

Analysis

Information Processing and Concept Attainment Analyses. The information processing scores were analyzed on the basis of (a) stimulus presentation and (b) response modes using analysis of variance procedures. Because these two conditions were not orthogonal in the design, a separate analysis was undertaken for each. Figure 1 showed the stimulus presentation and corresponding response options for the subtests involved in the information processing test. Through an examination of Figure 1 the reason for the two separate analyses becomes apparent. These two analyses were exactly the same for the examination of the organismic strata, i. e., sex and grade levels; but the analyses were different on the basis of the repeated measures, i. e., stimulus presentation or the response option. As a result, the interactions of organismic strata and the repeated measures were also different.

A 2 x 3 factorial design with repeated measures was used for the analysis of stimulus presentation. As indicated, the two level and three level variables were sex and grade, respectively. The repeated measures consisted of exemplar and nonexemplar items from each of the two subtests. In the analysis of variance performed on response options, the analysis of sex and grade--again in a 2 x 3 factorial design--was identical to the previous analysis; but in this analysis there were three response options as repeated measures rather than four presentation modes. The procedure discussed by Greenhouse and Geisser (1959) for a conservative test of repeated measures was used in these and other analyses involving repeated measures.

The time-to-criterion scores from all concept attainment problems were also analyzed using analysis of variance techniques. Again, a 2 x 3 factorial design with repeated measures was used. The binary and tertiary variables were again sex and grade level. The repeated measures in this instance were the four problems or concepts to be attained. These four problems were arranged in a 2 x 2 factorial pattern. Since exemplar-nonexemplar differences and problem differences could be appraised, the interaction of exemplar by problem could be analyzed. For a more complete description of this analysis see Tagatz (1963).

Because these problems were administered in a random sequence to the Ss, it was possible to further examine these data to determine the effect of ordinal position on efficiency of concept attainment. This analysis of repeated measures was also undertaken.

Duncan's Multiple Range Test was used as an a posteriori test to identify statistically significant differences in comparisons involving more than two groups. In order to reduce alpha error, the largest value was used in all comparisons.

Achievement Test Scores. After the answer sheets had been corrected, scores from the achievement tests were made available to the school providing the Ss. As these batteries have been standardized, no further analysis was undertaken to determine grade level increments and sex differences or grade by sex interactions. Rather the relationship of the achievement measures to each other and to the information processing and concept attainment problems were examined.

Factor Analyses. From the intercorrelations of the 30 achievement tests, 16 tests representing the five relatively distinct curricular groupings were selected for analysis. This subset of the total of the test batteries was selected by establishing the curricular validity of the fifteen tests using the convergent-divergent approach of the Campbell and Fiske (1959) multimethod-multitrait matrix. Those achievement tests which tended to be heavily confounded with several curricular areas were purged from the battery. Additionally, 14 tests representing concept attainment and information processing were included for analysis. Recall, however, that the information processing instances were arranged by type of information presentation and then by response option; the dependencies developed by this operation required the separation of these tests, along with the achievement and concept attainment tests, into two separate matrices of intercorrelations.

Each of these separate sets of data was analyzed using two data reduction models, Alpha Factor Analysis, Kaiser and Caffrey (1963) and Incomplete Image Analysis, Harris (1962). The two models were selected because of their scale-free characteristics. The first, the Alpha solution, rescales $R-U^2$ in the metric of the common parts. The second, the Incomplete Image solution, rescales $R-S^2$ in the metric of the unique parts. The factors of both solutions were rotated to the Harris-Kaiser (1964) oblique criterion; and the L matrix, the factor intercorrelations, were examined for relationships among curricular areas, concept attainment, and information processing.

# CHAPTER IV

## RESULTS

The results of the study are presented in the general order of the questions stated in the problem section of this paper. Because of their interrelationship, the third and fourth questions are considered in a combined section. The specific questions were:

1. What are the effects of the following variables upon information processing in concept attainment tasks: (a) grade level--seventh, eighth, and ninth; (b) sex; (c) exemplar or nonexemplar stimulus presentation; and (d) exemplar, nonexemplar, or indeterminant response options?
2. What are the effects of the following variables upon concept attainment: (a) grade level--seventh, eighth, and ninth; (b) sex; and (c) exemplar or nonexemplar stimulus presentation?
3. What are the common factors that account for the relationships among the concept attainment tasks and curricular achievement tests?
4. What are the relationships among laboratory variables and the curricular areas as determined by oblique relationships of the common (task and curricular) factors?

**Information Processing.** Table 1 presents the results of the analysis of variance of scores based on the exemplar-nonexemplar stimulus presentation of the information processing tasks. Two sources of

TABLE 1

Analysis of Variance of Scores Based on Exemplar-Nonexemplar Stimulus Presentation of the Information Processing Tasks

| Source | SS | df | MS | F | Level of Significance |
|---|---|---|---|---|---|
| Organismic Strata (OS) | (369.71) | | (73.94) | (4.90) | (.01) |
| Sex ($S_x$) | 13.00 | 1 | 13.00 | $<$ 1.00 | |
| Grade (G) | 197.21 | 2 | 98.60 | 6.54 | .01 |
| $S_x$ x G | 159.50 | 2 | 79.75 | 5.29 | .01 |
| Ss/OS | 1,718.62 | 114 | 15.08 | | |
| Repeated Measures (RM) | 34.61 | 3 | 11.54 | 2.44 | |
| OS x RM | 94.81 | 15 | 6.32 | 1.34 | |
| Ss/OS x RM | 1,614.33 | 342 | 4.72 | | |
| Grand Mean | 25,974.92 | 1 | | | |
| Total | 29.807.00 | 480 | | | |

variance were statistically significant, both at the .01 level. These were the grade level differences and the sex by grade level interaction. There was not a statistically significant difference between the males and females nor between the repeated measures--in this instance consisting of differences between exemplar and nonexemplar presentation.

Table 2 presents a further analysis of the significant differences

TABLE 2

Mean Scores for Grades Seven, Eight, and Nine and Duncan's Range From Scores Based on Exemplar-Nonexemplar Stimulus Presentation of the Information Processing Tasks

| Grade 7 | Grade 8 | Grade 9 | Duncan's Range |
|---|---|---|---|
| 27.75 | 28.00 | 33.02 | 3.48 |

among the grades. Duncan's Multiple Range was 3.48 in this instance, indicating that the statistically significant difference resulted because the 9th grade was different from both the 7th and 8th grades, but that the 7th and 8th grades were not statistically, significantly different from each other. The mean for the 7th grade was 27.25, for the 8th grade 28.00, and for the 9th grade 33.02. These data suggest that there is an increase in the ability to process information of the type involved in these tasks across those grade levels with the larger change occurring between the 8th and 9th grades. These findings are consistent with the theoretical formulation by Inhelder and Piaget; namely, that analytic-type thinking has its beginning at about the onset of adolescence and increases rapidly during the next several years. They found specifically that little analytic-type activity occurred prior to age 12 and a great deal was being used by age 16.

Table 3 indicates differential rate of development of ability to

TABLE 3

Mean Scores for Interaction of Grade by Sex and Duncan's Range From Scores Based on Exemplar-Nonexemplar Stimulus Presentation of the Information Processing Tasks

| | Grade 7 | Grade 8 | Grade 9 | Duncan's Range |
|---|---|---|---|---|
| Males | 24.85 | 30.60 | 30.85 | 5.41 |
| Females | 29.65 | 25.40 | 35.20 | |

perform the analytic-type tasks for males and females. Seventh grade males were significantly less efficient than were 8th and 9th grade males and 8th grade females. Seventh grade females were significantly less efficient than 9th grade females. Eighth grade females were significantly less efficient than 9th grade females and males. While it can be concluded that there is a differential rate of development of analytic ability in males and females of the grades studied, the complexity of the interaction suggests that additional information is needed.

Table 4 is another analysis performed on the scores of the information processing tasks. In this instance, however, the response options

TABLE 4

Analysis of Variance of Scores Based on Response Options of the Information Processing Tasks

| Source | SS | df | MS | F | Level of Significance |
|---|---|---|---|---|---|
| Organismic Strata (OS) | 492.98 | 5 | 98.60 | 4.90 | .01 |
| Ss/OS | 2,290.97 | 114 | 20.60 | | |
| Response Options (RO) | 1,304.22 | 2 | 652.11 | 50.79 | .01 |
| Os x RO | 80.88 | 10 | 8.09 | $<$ 1.00 | |
| Ss/OS x RO | 2,926.73 | 228 | 12.84 | | |
| Grand Mean | 34,633.22 | 1 | | | |
| Total | 41,729.00 | 360 | | | |

were of a different type. It will be recalled from Fig 4 that three responses were possible to the items which had been presented in exemplar and nonexemplar form. First, a card could be indeterminant in nature,

i. e., there would be an insufficient amount of information presented for a S to specify either the inclusion or the exclusion of the test card to the conceptual category. Second, the information presented to the S could require that the test card would be definitely another exemplar. Finally, the information presented to the S could be such that the test card was to be definitely excluded from the conceptual category. In Table 1 the repeated measures of stimulus presentation were not found to be statistically significant from each other. Here, however, on the basis of response options the difference was statistically significant beyond the .01 level.

Table 5 presents the means for the three response options and Duncan's Range. There was a statistically significant difference between

TABLE 5

Mean Scores For Response Options and Duncan's Range From Scores Based on Response Options of the Information Processing Tasks

| Response Options | | | Duncan's Range |
|---|---|---|---|
| Yes | No | Can't Tell | |
| 11.78 | 10.42 | 7.23 | 3.42 |

items of which the response options were indeterminant and those items in which enough information had been presented in order for Ss to determine conclusively the inclusion of the test card in the conceptual category. The mean score for items in which the test card was also an exemplar of the concept was 11.78. The mean score for items in which the test card was definitely a nonexemplar was 10.42. These were not significantly different from each other, which is in agreement with the conclusion based on exemplar-nonexemplar stimulus presentation. Items for which membership was indeterminant had as their mean 7.23. This was significantly different from the "yes" but not the "no" response option.

Concept Attainment Tasks. Table 6 presents the results of the analysis of variance of time-to-criterion scores with the four separate

TABLE 6

Analysis of Variance of Time-to-Criterion Scores With Four Problems as the Repeated Measure of the Concept Attainment Data

| Source | SS | df | MS | F | Level of Significance |
|---|---|---|---|---|---|
| Sex (S) | 15.80 | 1 | 15.80 | 1.40 | |
| Grade (G) | 95.44 | 2 | 47.77 | 4.22 | .05 |
| S x G | 10.13 | 2 | 5.07 | <1.00 | |
| Ss/Treatments | 1,290.19 | 114 | 11.32 | | |
| Repeated Measures (RM) | 533.33 | 3 | 184.44 | 22.33 | .01 |
| T x RM | 50.24 | 15 | 3.35 | <1.00 | |
| Ss/T x RM | 2,823.22 | 342 | 8.26 | | |
| Grand Mean | 5,647.77 | 1 | | | |
| Total | 10,486.11 | 480 | | | |

problems as the repeated measures. Two sources of variance were found to be significantly different. First, there was a statistically significant difference among the grades; and second, there was a statistically significant difference among the repeated measures. The interactions of the organismic strata or treatments, i. e., grade, sex, and grade by sex, and these repeated measures were not significant. This is reasonable because nothing should be found in the interaction except that which is the function of random assignment.

Table 7 presents the mean time-to-criterion scores for grades seven, eight, and nine and Duncan's Range. It will be noted that a

TABLE 7

Mean Scores for Grades Seven, Eight, and Nine and Duncan's Range from Time-to-Criterion Scores for the Concept Attainment Tasks

| Grade 7 | Grade 8 | Grade 9 | Duncan's Range |
|---|---|---|---|
| 4.02 | 3.32 | 2.95 | .80 |

significant difference exists between grades seven and nine. It is again concluded that a gradual increase in performance occurred from grade seven to grade nine with a larger but not statistically significant change occurring between seven and eight. The fact that the significant difference occurred at an earlier age than the information processing difference suggests that perhaps this task is ontogenetically easier than information processing.

Table 8 presents the mean scores for the four problems. The mean

TABLE 8

Mean Time-to-Criterion Scores for Four Problem Presentations Based on Concept Attainment Tasks

| Exemplar I | Exemplar II | Nonexemplar I | Nonexemplar II |
|---|---|---|---|
| 2.86 | 2.18 | 5.07 | 3.62 |

time for Exemplar Problem One was 2.86. The mean for Exemplar Problem Two, i. e., the second problem in which the presentation was made through the exemplar mode, was 2.18. When these problems were presented through an exemplar focus card and nonexemplar instances, the mean time-to-criterion was 5.07 for Problem One and 3.62 for Problem Two. Because these repeated measures were factorially arranged, a further breakdown of the repeated measures was made to determine the nature of the significant differences using appropriate error terms.

Table 9 presents this further breakdown of the three sources of

TABLE 9

Analysis of Variance of Time-to-Criterion Scores for Repeated Measures of Problems, Exemplars, and Problems by Exemplar Interaction for the Concept Attainment Tasks

| Source | SS | df | MS | F | Level of Significance |
|---|---|---|---|---|---|
| Exemplar (E) | 399.91 | 1 | 399.91 | 69.8964 | .01 |
| S/T x E | 671.27 | 114 | 5.89 | | |
| Problem (P) | 135.69 | 1 | 135.69 | 15.1439 | .01 |
| S/T x P | 1,022.09 | 114 | 8.96 | | |
| E x P | 17.73 | 1 | 17.73 | 1.7909 | |
| S/T x E x P | 1,128.85 | 114 | 9.90 | | |

variance. Two were statistically significant. The effect of the exemplar-nonexemplar dichotomy was significant, and the difference between Problem One and Problem Two was significant. It will be remembered that Problem One and Problem Two do not refer to the order of presentation. Rather, they refer to the two problems that were used and presented through exemplar-nonexemplar instances. The interaction of exemplar by problem was not significant. This is a reasonable finding because nothing should be in this interaction that was not a function of random assignment of the problems to the various ordinal positions. Table 10 presents the mean time-to-criterion scores for exemplar and

TABLE 10

Mean Times for Exemplar and Nonexemplar Presentations from Repeated Measures of Problems by Exemplar-Nonexemplar Interaction in the Concept Attainment Analysis

| Exemplar | Nonexemplar |
|---|---|
| 2.52 | 4.34 |

nonexemplar modes. The mean time for the exemplar problems was 2.52 minutes. For the nonexemplar problems the mean time was 4.34 minutes. Table 11 shows the mean time-to-criterion scores for Problem One and Problem Two. The means were 3.96 and 2.90 minutes, respectively.

TABLE 11

Mean Times for Problem One and Problem Two From Repeated Measures of Problems by Exemplar-Nonexemplar Interaction in the Concept Attainment Analysis

| Problem I | Problem II |
|---|---|
| 3.96 | 2.90 |

Table 12 is an analysis of variance of time scores for concept attainment problems with ordinal position as the repeated measure. In

TABLE 12

Analysis of Variance of Time Scores for Concept Attainment Problems with Ordinal Position as the Repeated Measure

| Source | SS | df | MS | F | Level of Significance |
|---|---|---|---|---|---|
| Sex (S) | 15.80 | 1 | 15.80 | 1.40 | |
| Grade (G) | 95.45 | 2 | 47.77 | 4.22 | .05 |
| S x G | 10.13 | 2 | 5.06 | <1.00 | |
| Ss/Treatments | 1,291.09 | 114 | 11.32 | | |
| Ordinal Position (OP) | 291.03 | 3 | 97.01 | 10.96 | .01 |
| T x OP | 106.88 | 15 | 7.12 | <1.00 | |
| Ss/Treatments x OP | 3,027.96 | 342 | 8.85 | | |
| Grand Mean | 5,647.77 | 1 | | | |
| Total | 10,486.11 | 480 | | | |

the design the four problems had been randomly assigned to the various ordinal positions; and hence, it was possible to examine these data on the basis of the Problem and exemplar-nonexemplar presentation of the problem; or it was possible to examine the ordinal position effect which was a random presentation of the data that had gone into the problem analysis. The total time for each S for all four problems remained exactly the same; and hence, the first portion of the analysis results in identical F-ratios for grade, sex, and the sex by grade interaction. What was different about the analysis was the ordinal position as a repeated measure in comparison to the factorial presentation of two problems presented through exemplar and nonexemplar instances. Following the random assignment of problems to ordinal position the data were not in a factorial arrangement. The four ordinal positions with the corresponding three degrees of freedom were analyzed as independent--but repeated--measures. This effect resulted in a significant F-ratio of 10.96, thus indicating that learning how to obtain concepts occurred across the ordinal positions from the first to the fourth. The interaction of the treatments, i. e., grade, sex, and their interaction and the ordinal positions was not significant.

Table 13 presents the mean times for concept attainment problems with ordinal position as the repeated measure and the Duncan's Range

TABLE 13

Mean Times for Concept Attainment Problems with Ordinal Position as the Repeated Measure and Duncan's Range

| Ordinal Position 1 | Ordinal Position 2 | Ordinal Position 3 | Ordinal Position 4 | Duncan's Range |
|---|---|---|---|---|
| 4.38 | 3.[illegible]7 | 2.94 | 2.43 | .82 |

which corresponds to these data. It will be noted that a significant difference occurred between Ordinal Position Two and Ordinal Position Three. There was not a significant difference between Ordinal Position One and Two nor between Ordinal Position Three and Four. This finding is in agreement with what was found by Meinke (1966).

*Factor Analyses.* Several results will be presented in this section. First, various psychometric factors will be reported. Since two factor analytic procedures--Alpha Factor Analysis and Incomplete Image Analysis--were used, their results will be presented according to these distinct groupings. Because of dependencies that existed between the information processing tests, arranged by type of presentation (exemplar-nonexemplar) and then rearranged by response option (yes, no, can't tell), separate factor analyses for these arrangements e required. The results of each will be presented separately.

*Psychometric considerations.* As described earlier, four curricular areas--mathematics, reading, social studies, and science--were originally hypothesized as being related to information processing and concept attainment. Thirty achievement tests representing these broad areas were originally administered. Sixteen achievement tests representing five areas were finally selected for analysis subsequent to the examination of the total matrix of intercorrelations presented in Appendix IV. The fifth curricular area that appeared as a relatively distinct cluster was spelling. Table 14 presents reliability estimates for each of the sixteen achievement tests.

Table 15 presents KR - 21 internal consistency coefficient for each of four information processing subtests arranged by type of information. These were computed from the data of the 120 Ss participating in this study.

Table 16 presents KR - 21 internal consistency coefficients for each of six information processing subtests arranged by response option, using the 120 Ss participating in this investigation.

TABLE 14

Reliability Estimate for Sixteen Achievement Tests

| Curricular Area | Test | Reliability Estimates* |
|---|---|---|
| Mathematics | SRA Arith. Concepts | .79 - .82 |
| | Stanford Arith. Concepts | .82 - .87 |
| | Stanford Arith. Application | .77 - .81 |
| | California Arith. Reasoning | .84 |
| Reading | SRA - Reading Vocabulary | .83 - .89 |
| | Stanford - Paragraph Meaning | .93 - .94 |
| | SRA - Reading Comprehension | .85 - .87 |
| Social Studies | SRA - References | .80 - .83 |
| | SRA - Charts | .85 |
| | STEP - Social Studies I | .91 |
| Spelling | Stanford - Spelling | .91 - .94 |
| | SRA - Spelling | .81 - .83 |
| | California - Spelling | .83 |
| Science | Stanford - Science | .90 |
| | STEP - Science I | .88 - .90 |
| | STEP - Science II | .88 - .90 |

* The range of reliability coefficients are reported among grades 7, 8, and 9 except where only single coefficients were reported by the test publishers.

TABLE 15

Reliability Estimates for Four Information Processing Subtests Arranged by Type of Information

| Subtest | Type of Information | Number of Items | $r_{tt}$ |
|---|---|---|---|
| 1 | Exemplar | 15 | .65 |
| 2 | Nonexemplar | 15 | .40 |
| 3 | Exemplar | 15 | .60 |
| 4 | Exemplar & Nonexemplar | 15 | .50 |

TABLE 16

Reliability Estimate for Six Information Processing Subtests Arranged by Type of Response

| Subtest | Type of Response | Number of Items | $r_{tt}$ |
|---|---|---|---|
| 1 | Yes | 10 | .65 |
| 1 | No | 10 | .42 |
| 1 | Can't Tell | 10 | .60 |
| 2 | Yes | 10 | .61 |
| 2 | No | 10 | .61 |
| 2 | Can't Tell | 10 | .58 |

Table 17 presents the means and standard deviations for the 16 achievement tests finally selected for the factor analyses and the 14 information processing and concept attainment tests used for the respective analyses.

Alpha Factor Analysis of the achievement, concept attainment, and information processing of exemplar-nonexemplar presentation. Table 18 presents the 24 x 4 derived factor matrix rotated to the independent cluster solution of the Harris-Kaiser (1964) criterion. The associated matrix of intercorrelations from which the factors were educed is presented in Appendix V. The percent of common variance associated with Factors I through IV was 38.32, 26.91, 13.10, and 21.66, respectively. The factors, their larger loadings and descriptions follow:

| Factor I: General Achievement Factor | Loadings |
|---|---|
| SRA - Spelling | .98 |
| Stanford - Paragraph Meaning | .94 |
| Stanford - Spelling | .92 |

TABLE 17

Means and Standard Deviations for Thirty Variables
Used in the Alpha Factor Analyses

| | Test | Mean | Standard Deviation |
|---|---|---|---|
| 1. | Presentation of Exemplars (Subtest I) | 7.02 | 3.27 |
| 2. | Presentation of Nonexemplars (Subtest I) | 7.24 | 2.49 |
| 3. | Presentation of Exemplars (Subtest II) | 7.53 | 3.08 |
| 4. | Presentation of Nonexemplars (Subtest II) | 7.07 | 2.73 |
| 5. | Exemplar Problem I | 2.85 | 2.67 |
| 6. | Exemplar Problem II | 2.17 | 2.35 |
| 7. | Nonexemplar Problem I | 5.06 | 3.59 |
| 8. | Nonexemplar Problem II | 3.61 | 3.24 |
| 9. | Stanford - Arithmetic Application | 15.40 | 6.64 |
| 10. | California - Arithmetic Reasoning | 35.05 | 9.57 |
| 11. | Stanford - Arithmetic Concepts | 21.73 | 8.56 |
| 12. | SRA - Arithmetic Concepts | 19.44 | 6.39 |
| 13. | SRA - Reading Vocabulary | 27.28 | 11.59 |
| 14. | Stanford - Spelling | 31.65 | 12.49 |
| 15. | California - Spelling | 18.61 | 6.69 |
| 16. | SRA - Spelling | 21.26 | 7.50 |
| 17. | Stanford - Paragraph Meaning | 33.31 | 12.96 |
| 18. | SRA - Reading Comprehension | 25.22 | 10.89 |
| 19. | SRA - References | 29.18 | 7.80 |
| 20. | SRA - Charts | 24.11 | 10.57 |
| 21. | STEP - Social Studies I | 20.88 | 8.40 |
| 22. | Stanford - Science | 31.61 | 11.79 |
| 23. | STEP - Science I | 16.19 | 5.95 |
| 24. | STEP - Science II | 14.28 | 6.87 |
| 25. | Response Yes - Subtest I | 5.44 | 2.65 |
| 26. | Response No - Subtest I | 4.47 | 2.09 |
| 27. | Response Can't Tell - Subtest I | 4.27 | 2.48 |
| 28. | Response Yes - Subtest II | 6.08 | 2.47 |
| 29. | Response No - Subtest II | 5.80 | 2.50 |
| 30. | Response Can't Tell - Subtest II | 3.11 | 2.25 |

| Factor I: General Achievement Factor (cont.) | Loadings |
|---|---|
| SRA - Reading Comprehension | .90 |
| SRA - Reading Vocabulary | .89 |
| California - Spelling | .88 |

TABLE 16

Derived Factors of $R-U^2$, Alpha Solution, Harris-Kaiser Oblique Independent Cluster Criterion

| | Test | I | II | III | IV** |
|---|---|---|---|---|---|
| 1. | Presentation of Exemplars (Subtest I) | .06 | .80* | .09 | .09 |
| 2. | Presentation of Nonexemplars (Subtest I) | -.24 | .60* | -.22 | -.17 |
| 3. | Presentation of Exemplars (Subtest II) | .11 | .71* | .11 | .19 |
| 4. | Presentation of Nonexemplars ( Subtest II) | .07 | .51* | -.07 | -.15 |
| 5. | Exemplar Problem I | .06 | .02 | .17 | .70* |
| 6. | Exemplar Problem II | -.13 | -.06 | -.35* | .13 |
| 7. | Nonexemplar Problem I | -.02 | .06 | .34* | .14 |
| 8. | Nonexemplar Problem II | .23 | .05 | -.24 | .67* |
| 9. | Stanford - Arithmetic Application | .62* | .22 | .02 | -.11 |
| 10. | California - Arithmetic Reasoning | .53* | .21 | -.01 | -.23 |
| 11. | Stanford - Arithmetic Concepts | .68* | .06 | -.04 | -.20 |
| 12. | SRA - Arithmetic Concepts | .59* | .12 | -.06 | -.22 |
| 13. | SRA - Reading Vocabulary | .89* | -.12 | -.06 | -.10 |
| 14. | Stanford - Spelling | .92* | -.24 | -.09 | -.01 |
| 15. | California - Spelling | .88* | -.24 | -.19 | -.03 |
| 16. | SRA - Spelling | .98* | -.28 | -.06 | -.03 |
| 17. | Stanford - Paragraph Meaning | .94* | -.04 | .03 | -.03 |
| 18. | SRA - Reading Comprehension | .90* | -.01 | .09 | -.00 |
| 19. | SRA - References | .86* | .00 | .01 | -.05 |
| 20. | SRA - Charts | .74* | -.01 | .03 | -.23 |
| 21. | STEP - Social Studies I | .84* | .11 | .06 | .09 |
| 22. | Stanford - Science | .80* | .16 | .01 | .06 |
| 23. | STEP - Science I | .86* | .13 | .07 | .14 |
| 24. | STEP - Science II | .84* | .14 | .01 | .15 |

* Loadings contributing to the identification of factors
** Reflected

Factor I: General Achievement Factor (cont.)

| | Loadings |
|---|---|
| STEP - Science I | .86 |
| SRA - References | .86 |
| STEP - Science II | .84 |
| STEP - Social Studies I | .84 |
| Stanford - Science | .80 |
| SRA - Charts | .74 |

| Factor I: | General Achievement Factor (cont.) | Loadings |
|---|---|---|
| | Stanford - Arithmetic Concepts | .68 |
| | Stanford - Arithmetic Application | .62 |
| | SRA - Arithmetic Concepts | .59 |
| | California - Arithmetic Reasoning | .53 |

This factor is clearly a general factor associated with all of the achievement tests; reading comprehension and spelling tests are the most representative of the factor. The Alpha solution, rescaling $R-U^2$ in the metric of the common parts, is typically a few factor solution. It will be seen later that Incomplete Image Analysis, typically a many factor solution, breaks this general factor into several common curricular factors.

| Factor II: | Information Processing of Exemplar-Nonexemplar Presentations | Loadings |
|---|---|---|
| | Presentation of Exemplars #1 | .80 |
| | Presentation of Exemplars #2 | .71 |
| | Presentation of Exemplar-Nonexemplar #1 | .60 |
| | Presentation of Exemplar-Nonexemplar #2 | .51 |

This is an information processing factor representing the items arranged by type of information in the stimulus-material presentation.

| Factor III: | Concept Attainment I | Loadings |
|---|---|---|
| | Exemplar Information #2 | .35 |
| | Exemplar-Nonexemplar Information #1 | -.34 |
| Factor IV: | Concept Attainment II | |
| | Exemplar Information #1 | .70 |
| | Exemplar-Nonexemplar Information #2 | .67 |

Both of the concept attainment factors are group factors representing the concept attainment performances.

*Factor relationships.* Table 19 presents the 4 x 4 matrix of intercorrelations of the Alpha Factors. It is from this matrix that the

TABLE 19

Matrix of Intercorrelations of Four Alpha Factors

| | | I | II | III | IV |
|---|---|---|---|---|---|
| General Achievement | I | 1.00 | .60 | .18 | .65 |
| Information Processing of Presented Information | II | | 1.00 | .11 | .54 |
| Concept Attainment I | III | | | 1.00 | .11 |
| Concept Attainment II | IV | | | | 1.00 |

relationship of concept attainment, information processing of exemplar-nonexemplar presentation, and school achievement is suggested. A high degree of correlation can be seen to exist between the General Achievement Factor and the well defined Information Processing Factor of exemplar-nonexemplar presentation, and Concept Attainment II Factors. Concept Attainment I is a less well defined factor (low loadings) and is not highly related to the General Achievement Factor.

Alpha Factor Analysis of the achievement and information processing of response options scores. Table 20 presents the 22 x 3 factor matrix rotated to the independent cluster solution of the Harris-Kaiser (1964) criterion. The associated matrix of test intercorrelations, from which the three Alpha Factors were educed, is presented in Appendix VI. The

TABLE 20

Derived Factors of R-U$^2$, Alpha Solution, Harris-Kaiser Oblique Independent Cluster Criterion

| Test | I | II | III |
|---|---|---|---|
| 1. Response Yes #1 | -.11 | -.09 | .85* |
| 2. Response No #1 | .01 | -.32* | .20 |
| 3. Response Can't Tell #1 | -.18 | .70* | .58* |
| 4. Response Yes #2 | -.13 | .07 | .62* |
| 5. Response No #2 | -.11 | -.72* | .63* |
| 6. Response Can't Tell #2 | .10 | .43* | .34 |
| 7. Stanford - Arithmetic Application | .51 | -.04 | .40* |
| 8. California - Arithmetic Reasoning | .45 | .01 | .47* |
| 9. Stanford - Arithmetic Concepts | .67 | .02 | .23 |
| 10. SRA - Arithmetic Concepts | .61 | .03 | .28 |
| 11. SRA - Reading Vocabulary | .97* | -.06 | -.09 |
| 12. Stanford - Spelling | 1.00* | .02 | -.28 |
| 13. California - Spelling | .96* | -.01 | -.28 |
| 14. SRA - Spelling | 1.00* | .00 | -.34 |
| 15. Stanford - Paragraph Meaning | .90* | .04 | .03 |
| 16. SRA - Reading Comprehension | .86* | -.01 | .04 |
| 17. SRA - References | .83* | -.04 | .08 |
| 18. SRA - Charts | .80* | .07 | .12 |
| 19. STEP - Social Studies I | .71 | -.04 | .16 |
| 20. Stanford - Science | .71 | -.08 | .19 |
| 21. STEP - Science I | .75 | .10 | .10 |
| 22. STEP - Science II | .74 | .00 | .10 |

* Loadings contributing to the identification of factors

percent of common variance associated with Factors I, II, and III was 41.23, 28.60, and 30.17, respectively. The factors, their major loadings and descriptions follow:

| Factor I: Language Arts | Loadings |
|---|---|
| SRA - Spelling | 1.00 |
| Stanford - Spelling | 1.00 |
| SRA - Reading Vocabulary | .97 |

| Factor I: | Language Arts (cont.) | Loadings |
|---|---|---|
| | California - Spelling | .96 |
| | Stanford - Paragraph Meaning | .90 |
| | SRA - Reading Comprehension | .86 |
| | SRA - References | .83 |
| | SRA - Charts | .80 |

This is an achievement factor with the largest loadings represented by the language arts tests.

| Factor II: | Information Processing - No, Can't Tell | Loadings |
|---|---|---|
| | Response No #2 | -.72 |
| | Response No #1 | -.32 |
| | Response Can't Tell #2 | .43 |
| | Response Can't Tell #1 | .70 |

This is a psychologically interesting bi-polar factor representing "no" and "can't tell" responses to the information processing tests.

| Factor III: | Information Processing of Response Options - Arithmetic | |
|---|---|---|
| | Response Yes #1 | .85 |
| | Response No #2 | .63 |
| | Response Yes #2 | .62 |
| | Response Can't Tell #1 | .58 |
| | California - Arithmetic Reasoning | .47 |
| | Stanford - Arithmetic Application | .40 |

This seems to be a factor representing both the information processing and arithmetic tests. It was the single bit of information indicating a differential relationship between the curricular areas and concept learning that appeared in the Alpha Factor Analyses.

Factor relationships. Table 21 presents the 3 x 3 matrix of intercorrelations of the three Alpha Factors. It is from this matrix that the

TABLE 21

Matrix of Intercorrelations of Three Alpha Factors

| | | I | II | III |
|---|---|---|---|---|
| Language Arts | I | 1.00 | .01 | .73 |
| Information Processing: No-Can't Tell | II | | 1.00 | .01 |
| Information Processing: Response Options - Arithmetic | III | | | 1.00 |

relationship between information processing of response option scores and school achievement is suggested. A high degree of relationship, .73, can be seen to exist between the Language Arts Factor (reading, spelling, and social studies) and the information processing instances arranged by positive response option. The instance arranged by "no" and "can't tell" response options are not highly related to the Language Arts Factor.

Incomplete Image Analysis of the achievement, concept attainment, and information processing of exemplar-nonexemplar presentation. There were two factor analytic models used in the study; namely, Alpha Factor Analysis and Incomplete Image Analysis. Alpha Factor Analysis, typically a few factor solution, produced the general achievement factor and several factors representing the concept attainment and information processing tests reported in the previous section. Incomplete Image Analysis, typically a many factor solution, is presented in this section. The purpose of this additional analysis was to attempt to differentiate the general achievement factor into the hypothesized curricular areas and to examine their relation to information processing and concept attainment. Table 22 presents the 24 x 14 derived factors of $R\text{-}S^2$, Incomplete Image solution, rotated to the independent cluster solution of the Harris-Kaiser (1964) oblique criterion. The associated matrix of intercorrelations is presented in Appendix V. The factors, their larger loadings, and descriptions follow:

| | | Loadings |
|---|---|---|
| Factor I: | Mathematics I | |
| | Stanford - Arithmetic Application | .87 |
| | California - Arithmetic Reasoning | .43 |
| | Stanford - Arithmetic Concepts | .43 |
| Factor II: | Spelling | |
| | Stanford - Spelling | 1.00 |
| | California - Spelling | .65 |
| | SRA - Language Arts (Spelling) | .77 |
| Factor III: | Reading | |
| | SRA - Reading Comprehension | 1.00 |
| | SRA - Reading Vocabulary | .88 |
| | Stanford - Paragraph Meaning | .38 |

TABLE 22

Derived Factors of $R-S^2$, Incomplete Image Solution
Harris-Kaiser Oblique Criterion

| | | I | II** | III | IV | V** | VI | VII** | VIII | IX | X** | XI | XII | XIII | XIV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Presentation of Exemplars (Subtest I) | -.20 | .02 | -.08 | .14 | -.10 | .01 | .76* | -.10 | -.11 | -.07 | .15 | -.09 | .05 | .16 |
| 2. | Presentation of Nonexemplars (Subtest I) | -.02 | .03 | .01 | .60* | .20 | -.16 | .20 | .09 | .12 | -.06 | -.02 | -.16 | .04 | -.04 |
| 3. | Presentation of Exemplars (Subtest II) | .22 | -.05 | -.06 | -.03 | .06 | .08 | .91* | .19 | .05 | .15 | -.19 | .15 | -.04 | -.26 |
| 4. | Presentation of Nonexemplars (Subtest II) | .33 | .15 | .05 | .34* | -.42 | .01 | .04 | -.17 | .02 | -.09 | .54 | .48 | -.07 | .47 |
| 5. | Exemplar Problem I | -.05 | .27 | .11 | -.05 | -.12 | -.02 | .07 | -.08 | -.03 | 1.00* | .08 | -.04 | .01 | .22 |
| 6. | Exemplar Problem II | -.11 | -.02 | .27 | .08 | -.05 | .08 | .02 | -.08 | .01 | -.00 | -.21 | -.06 | .54 | .03 |
| 7. | Nonexemplar Problem I | .03 | .00 | -.05 | -.14 | .01 | -.11 | .10 | .09 | -.60 | .06 | .04 | .03 | -.01 | .08 |
| 8. | Nonexemplar Problem II | .52 | -.24 | -.55 | -.29 | .25 | -.23 | .07 | .43 | .21 | .35* | .57 | .55 | .18 | -.23 |
| 9. | Stanford - Arith. Application | .87* | .07 | .09 | .03 | .06 | -.04 | .01 | -.09 | .00 | .01 | -.11 | -.03 | -.02 | .06 |
| 10. | California - Arithmetic Reas. | .43* | -.14 | .03 | -.02 | -.02 | .56* | .01 | .07 | -.06 | -.14 | .07 | .07 | .04 | -.12 |
| 11. | Stanford - Arith. Concepts | .43* | -.02 | -.14 | -.07 | -.15 | -.01 | -.01 | .02 | .02 | -.04 | .10 | -.57 | .02 | .05 |
| 12. | SRA - Arithmetic Concepts | -.22 | .10 | .02 | -.02 | .03 | .88* | .03 | -.07 | .05 | .07 | .01 | -.08 | -.01 | .10 |
| 13. | SRA - Reading Vocabulary | -.02 | -.01 | .88* | -.01 | -.12 | -.02 | -.05 | .08 | .07 | .02 | .01 | -.04 | .01 | .10 |
| 14 | Stanford - Spelling | -.03 | 1.00* | -.14 | -.02 | .01 | .01 | .05 | -.24 | .02 | .07 | .01 | -.18 | -.01 | -.01 |
| 15. | California - Spelling | -.08 | .65* | -.20 | -.11 | -.07 | -.03 | .02 | .06 | -.02 | -.30 | .16 | .14 | .10 | .23 |
| 16. | SRA - Spelling | .12 | .77* | .16 | .06 | .05 | .02 | -.09 | .32 | -.03 | .04 | -.08 | .16 | -.01 | -.14 |
| 17. | Stanford - Paragraph Meaning | -.04 | .16 | .38* | -.19 | .03 | -.13 | .22 | -.10 | .07 | -.16 | .02 | -.08 | -.04 | .14 |
| 18. | SRA - Reading Comprehension | .06 | -.05 | 1.00* | -.00 | .11 | .04 | .02 | -.04 | -.07 | .02 | .03 | .09 | .01 | -.13 |
| 19. | SRA - References | -.09 | -.07 | .04 | .02 | -.03 | -.02 | .04 | .80 | -.01 | -.04 | .03 | -.14 | -.01 | .08 |
| 20. | SRA - Charts | -.05 | .06 | .01 | .04 | .06 | .02 | -.01 | .08 | .00 | .03 | .00 | -.85 | .00 | -.04 |
| 21. | STEP - Social Studies I | -.16 | -.02 | .11 | -.00 | .09 | .06 | -.03 | .04 | -.02 | .02 | .80 | -.12 | -.04 | -.12 |
| 22. | Stanford - Science | .06 | -.09 | -.01 | -.01 | .12 | .03 | -.03 | .09 | -.02 | .07 | -.08 | .02 | .01 | .92 |
| 23. | STEP - Science I | .00 | .03 | -.13 | -.01 | .85* | .11 | .01 | .11 | .03 | -.04 | -.06 | .14 | -.05 | .10 |
| 24. | STEP - Science II | .05 | -.00 | .16 | .06 | .72* | -.14 | -.02 | -.21 | -.04 | -.00 | .13 | -.21 | .06 | .01 |

* Loadings contributing to the identification of factors ** Reflected

| | | Loadings |
|---|---|---|
| Factor IV: | Information Processing - Negative Information | |
| | Presentation of Nonexemplars (Subtest I) | .60 |
| | Presentation of Nonexemplars (subtest II) | .34 |
| Factor V: | Science | |
| | STEP - Science I | .85 |
| | STEP - Science II | .72 |
| Factor VI: | Mathematics II | |
| | SRA - Arithmetic Concepts | .88 |
| | California - Arithmetic Reasoning | .56 |
| Factor VII: | Information Processing - Positive Information | |
| | Presentation of Exemplars (Subtest II) | .91 |
| | Presentation of Exemplars (Subtest I) | .76 |
| Factors VIII - IX: | Uninterpreted | |
| Factor X: | Concept Attainment - Exemplar Presentation | |
| | Exemplar Problem I | 1.00 |
| | Nonexemplar Problem II | .35 |
| Factors XI - XIV: | Uninterpreted | |

Table 23 presents the matrix of factor intercorrelations for the first 10 Incomplete Image Factors. It is from this matrix that the relationship of curricular area, concept attainment, and information processing of presented information is suggested. In this matrix it can be seen that there exists a generally high, positive relationship between the curricular

TABLE 23

Matrix of Intercorrelations of 10 Incomplete Image Factors

| | | I | II* | III | IV | V* | VI* | VII* | VIII | IX | X |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mathematics I | I | 1.00 | .73 | .30 | .21 | .74 | .90 | .75 | .76 | .54 | .81 |
| Spelling | II | | 1.00 | .35 | .39 | .77 | .72 | .51 | .91 | .45 | .30 |
| Reading | III | | | 1.00 | .31 | .86 | .82 | .63 | .87 | .53 | .77 |
| Nonexemplar Information Processing | IV | | | | 1.00 | .26 | .17 | -.12 | .31 | .23 | .12 |
| Science | V | | | | | 1.00 | .75 | .67 | .32 | .46 | .69 |
| Mathematics II | VI | | | | | | 1.00 | .75 | .79 | .54 | .36 |
| Exemplar Information Processing | VII | | | | | | | 1.00 | .63 | .36 | .62 |
| ? | VIII | | | | | | | | 1.00 | .52 | .80 |
| ? | IX | | | | | | | | | 1.00 | .54 |
| Concept Attainment of Exemplar Information | X | | | | | | | | | | 1.00 |

* Reflected

and concept learning factors. Information processing and concept attainment tests represented by exemplar instances had the highest relationships with the various curricular areas.

Incomplete Image Analysis of the achievement and the information processing of response option scores. Table 24 presents the 22 x 12 factor matrix of $R-S^2$, Incomplete Image Solution, rotating to the independent cluster solution of the Harris-Kaiser (1964) criterion. The associated matrix of test intercorrelations, from which the Image Factors were educed, is presented in Appendix VI. The factors, their major loadings, and descriptions follow:

| Factor I: | Common Achievement | Loadings |
|---|---|---|
| | Stanford - Arithmetic Concepts | .96 |
| | SRA - Charts | .86 |
| | STEP - Social Studies I | .49 |
| | Stanford - Paragraph Meaning | .28 |
| | SRA - References | .25 |

This appears to be an achievement factor common to the areas of social studies and mathematics.

Factor II: Uninterpreted

| Factor III: | Information Processing: Response Option, "can't tell" | Loadings |
|---|---|---|
| | Response Can't Tell #1 | .77 |
| | Response Can't Tell #2 | .73 |
| Factor IV: | Reading | |
| | SRA - Reading Comprehension | 1.00 |
| | SRA - Reading Vocabulary | .92 |
| | Stanford - Paragraph Meaning | .49 |

TABLE 24

Derived Factors of R-$S^2$ Incomplete Image Solution
(Harris-Kaiser Oblique Criterion)

| | Tests | I** | II** | III | IV | V | VI** | VII | VIII** | IX** | X | XI** | XII** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Response Yes #1 | -.02 | .05 | .09 | -.22 | .80* | -.09 | .11 | -.18 | -.03 | -.14 | .33 | .22 |
| 2. | Response No #1 | -.02 | -.01 | -.02 | .05 | .02 | .07 | .66* | .19 | -.00 | .07 | .09 | -.09 |
| 3. | Response Can't Tell #1 | -.07 | .27 | .77* | -.03 | .00 | .03 | -.13 | .06 | .14 | -.06 | -.33 | -.09 |
| 4. | Response Yes #2 | -.39 | -.09 | -.05 | -.04 | .86* | .05 | -.14 | .45 | .12 | .26 | -.34 | -.33 |
| 5. | Response No #2 | -.05 | .97 | -.10 | .10 | .20 | -.17 | .22* | -.29 | .04 | -.03 | -.34 | .11 |
| 6. | Response Can't Tell #2 | .09 | -.24 | .73* | .06 | .05 | -.06 | .10 | -.07 | -.13 | .07 | .28 | .09 |
| 7. | Stanford - Arithmetic Application | .20 | -.02 | .01 | .07 | .04 | .08 | .05 | -.07 | -.01 | .58 | .03 | .06 |
| 8. | California - Arithmetic Reasoning | .11 | .16 | .04 | .00 | -.02 | .03 | .01 | -.01 | .69* | .18 | -.13 | -.12 |
| 9. | Stanford - Arithmetic Concepts | .96* | .08 | -.04 | -.14 | .01 | -.08 | -.06 | -.06 | -.00 | .15 | -.02 | .03 |
| 10. | SRA - Arithmetic Concepts | .02 | -.14 | .05 | .07 | .03 | -.04 | -.01 | -.04 | .90* | -.18 | .13 | .12 |
| 11. | SRA - Reading Vocabulary | .10 | .02 | -.01 | .92* | -.06 | -.17 | -.01 | .08 | -.03 | -.03 | -.03 | .11 |
| 12. | Stanford - Spelling | .01 | .03 | -.01 | -.04 | .05 | -.03 | .01 | -.02 | .04 | .02 | .91* | -.02 |
| 13. | California - Spelling | -.01 | .65 | .05 | -.15 | -.09 | .03 | -.11 | .19 | .00 | -.05 | .24* | .02 |
| 14. | SRA - Spelling | -.23 | .21 | -.01 | .12 | -.11 | .08 | -.01 | .64 | -.02 | .12 | .23* | -.13 |
| 15. | Stanford - Paragraph Meaning | .28* | .05 | -.05 | .49* | .21 | .08 | -.12 | -.07 | -.13 | -.02 | .14 | -.03 |
| 16. | SRA - Reading Comprehension | -.21 | -.06 | .03 | 1.00* | .01 | .11 | .03 | -.05 | .03 | .05 | -.01 | -.08 |
| 17. | SRA - References | .25* | -.09 | .00 | -.03 | .08 | -.06 | .05 | .94 | -.03 | -.01 | -.13 | .11 |
| 18. | SRA - Charts | .86* | -.11 | .04 | .05 | -.07 | .05 | .04 | .15 | .07 | -.07 | -.03 | -.06 |
| 19. | STEP - Social Studies I | .49* | .20 | .03 | .21 | .11 | .41 | .06 | -.09 | -.03 | -.33 | -.04 | -.08 |
| 20. | Stanford - Science | -.12 | .07 | .01 | .03 | .01 | .13 | -.03 | .06 | .01 | .10 | -.04 | .67 |
| 21. | STEP - Science I | -.17 | -.12 | -.02 | -.20 | .01 | .90* | -.05 | .21 | .14 | .00 | -.00 | .12 |
| 22. | STEP - Science II | .12 | -.06 | -.00 | -.08 | -.03 | .99* | .04 | -.18 | -.12 | .02 | -.02 | -.04 |

*

* Loadings contributing to the identification of factors

** Reflected

| | | |
|---|---|---|
| Factor V: | Information Processing: Response Option, "yes" | |
| | Response Yes #2 | .86 |
| | Response Yes #1 | .80 |
| Factor VI: | Science | |
| | STEP - Science II | .99 |
| | STEP - Science I | .90 |
| Factor VII: | Information Processing: Response Option, "no" | |
| | Response No #1 | .66 |
| | Response No #2 | .22 |
| Factor VIII: | Uninterpreted | |
| Factor IX: | Mathematics | |
| | SRA - Arithmetic Concepts | .90 |
| | California - Arithmetic Reasoning | .69 |
| Factor X: | Uninterpreted | |
| Factor XI: | Spelling | |
| | Stanford - Spelling | .91 |
| | California - Spelling | .24 |
| | SRA - Language Arts III (Spelling) | .23 |
| Factor XII: | Uninterpreted | |

Table 25 presents the 12 x 12 matrix of factor intercorrelations for the 12 Incomplete Image Factors. In this analysis the information processing instances were arranged by response option and three factors representing the three decisions were identified. It can be seen that though modest relationships generally existed between the information processing tests and the various curricular areas, the factor of "yes" response options resulted in correlations equal to or in excess of .70 with all of the curricular factors except spelling.

TABLE 25

Matrix of Intercorrelations of 12 Incomplete Image Factors

| | | I | II | III* | IV* | V* | VI | VII | VIII | IX | X* | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Achievement | I | 1.00 | .83 | .39 | .91 | .78 | .86 | .23 | .86 | .92 | .86 | .78 | .92 |
| ? | II | | 1.00 | .14 | .83 | .70 | .77 | .10 | .87 | .78 | .74 | .85 | .81 |
| Response Option - Can't Tell | III | | | 1.00 | .32 | .41 | .42 | .27 | .33 | .39 | .30 | .30 | .29 |
| Reading | IV | | | | 1.00 | .70 | .91 | .21 | .89 | .83 | .70 | .82 | .92 |
| Response Option - Yes | V | | | | | 1.00 | .72 | .00 | .64 | .83 | .76 | .47 | .77 |
| Science | VI | | | | | | 1.00 | .21 | .85 | .81 | .69 | .78 | .90 |
| Response Option - No | VII | | | | | | | 1.00 | .29 | .22 | .19 | .37 | .06 |
| ? | VIII | | | | | | | | 1.00 | .79 | .65 | .91 | .79 |
| Mathematics | IX | | | | | | | | | 1.00 | .86 | .67 | .84 |
| ? | X | | | | | | | | | | 1.00 | .63 | .82 |
| Spelling | XI | | | | | | | | | | | 1.00 | .70 |
| ? | XII | | | | | | | | | | | | 1.00 |

* Reflected

Table 26 presents a summary of the relationship of the curricular factors and the concept learning factors for the two Incomplete Image Analyses. It will be recalled that the Incomplete Image Analyses were undertaken in order to break the general achievement factors into their respective subject areas. Table 26 indicated that both of the Incomplete Image Analyses did this quite well. The table further shows a generally higher relationship between the five curricular factors and concept attainment of exemplar type information and information processing of exemplar type information. It should be noted, however, that the Nonexemplar Information Processing Factor, the Information Processing of Response Option--"No" and the Information Processing of Response Option--"Can't Tell" Factor also correlated significantly, but to a lesser degree, with certain of the curricular factors.

TABLE 26

Summary Matrix of Curricular and Concept Learning Factors for the Two Incomplete Image Analyses

| | | First Incomplete Image Analysis—Achievement, Concept Attainment and Information Processing of Presented Instances | | | Second Incomplete Image Analysis—Achievement and Information Processing of Response Options | | |
|---|---|---|---|---|---|---|---|
| | | Nonexemplar Information Processing Table 23, Factor IV | Exemplar Information Processing Table 23, Factor III | Concept Attainment Exemplar Information Table 23, Factor X | Information Processing Response Option—Yes Table 25, Factor V | Information Processing Response Option—No Table 25, Factor VII | Information Processing Response Option—Can't Tell Table 25, Factor III |
| Mathematics | Table 23 Factor VI | .17 | .75 | .86 | — | — | — |
| | Table 25 Factor IX | — | — | — | .33 | .22 | .39 |
| Spelling | Table 23 Factor II | .39 | .51 | .81 | — | — | — |
| | Table 25 Factor XI | — | — | — | .47 | .37. | .30 |
| Reading | Table 23 Factor III | .31 | .63 | .57 | — | — | — |
| | Table 25 Factor IV | — | — | — | .70 | .21 | .32 |
| Science | Table 23 Factor V | .26 | .67 | .69 | — | — | — |
| | Table 25 Factor VI | — | — | — | .72 | .21 | .42 |
| Mathematics | Table 23 Factor I | .21 | .75 | .81 | — | — | — |

## CHAPTER V

## CONCLUSIONS AND DISCUSSION

The organization of this Conclusions and Discussion chapter conforms to the order of the Results chapter. The questions under examination in the study are presented separately except that the two questions regarding factor analyses are again considered in a combined section.

1. What are the effects of the following variables upon information processing in concept attainment tasks: (a) grade level--seventh, eighth, and ninth; (b) sex; (c) exemplar or nonexemplar stimulus presentation; and (d) exemplar, nonexemplar, or indeterminant response options?

Grade Level. From the results of the information processing data, it is concluded that a significant difference exists in the ability of junior high school youngsters to do problems of the type represented by the Information Processing Test. Whether this difference results because of gradual development or because of ontogenetic stages is not clear. The statistically significant difference in this study resulted because the ninth grade Ss were more efficient than seventh and eighth grade Ss. Supportive of the "stage" hypothesis is the fact that the seventh and eighth grade Ss were not significantly different from each other. However, the means of the three grade levels indicated continuous improvement, thus suggesting the correctness of a continuous development explanation. Proof of the stage-development hierarchy could be accepted if youngsters prior to a particular chronological or mental age were not able to and subsequently were able to do a task. Evidence of this type was not forthcoming from the data in the present study. Hence, it is concluded that (1) the information processing items are of appropriate difficulty for junior high school youngsters and (2) if developmental stages were to be identified, the information processing tasks would have to be administered to younger Ss who may not be able to perform analytic-type thought as required in these tasks. Ss in this study were of ages in which analytic-type thinking is present according to Inhelder and Piaget (1958). As such, the scores were appropriate for the factor-analytic part of this study.

Sex. In the present study sex differences were not evident in the information processing tasks. This concurs with what is usually found in concept learning studies using older Ss. There was, however, an interaction of grade and sex. This interaction was quite complicated, but it seemed that there may have been a retarded development in the males at the younger age.

Exemplar vs. Nonexemplar Information Processing. Ss in the present study processed exemplar and nonexemplar information equally well; and hence, it is concluded that these types of instances are of equal difficulty. When ambiguity was introduced into the information processing, however, as when the response option to items was indeterminant, it was found that Ss did less well than with exemplar presentation. This suggests that the results of other research--such as the article by Smoke (1932) and the concept attainment section of this study where exemplar information was found to most readily facilitate concept attainment--occurred because the informational presentation of the stimulus material was ambiguous to the Ss. The present findings are a replication of the results reported by Tagatz (1963) and Tagatz and Meinke (1966) of a similar information processing experiment.

2. What are the effects of the following variables upon concept attainment: (a) grade level--seventh, eighth, and ninth; (b) sex; and (c) exemplar or nonexemplar stimulus presentation?

Grade Level. It is concluded that there is a statistically significant difference among Ss in junior high school grade in ability to attain concepts imbedded in dichotomously dimensionalized stimulus materials. Unlike the information processing analysis, the minimum statistically significant difference in the concept attainment problems occurred between grade seven and grade eight. Again, however, an examination of the mean time-to-criterion scores indicated that there is a gradual increment in performance from grade seven to grade nine, thus supporting a gradual development hypothesis for youngsters of the junior high level.

Sex. The results of the analysis of time-to-criterion scores for the concept attainment problems indicates that the sex of a person does not influence ability to attain concepts of the type represented by the problems of this study. Additionally, in this analysis sex did not interact with any of the other main effects in the analysis. This finding then concurs with what is usually found in concept learning studies. Specifically, this finding is in agreement with Nelson (1958) (1960) who worked with younger children in the intermediate grades and with both Tagatz (1963) and Meinke (1966) who worked with older Ss

Exemplar or Nonexemplar Stimulus Presentation. From the analysis of the mean time-to-criterion scores for the exemplar and nonexemplar stimulus presentation, it is concluded that Ss of the junior high level find exemplar instances less difficult than instances where nonexemplars are presented in addition to an exemplar focus card. In the construction of the problems used in the present study, care was taken to equate the information yield of the exemplar and nonexemplar problems just as the information yield of the items in the Information Processing Test were also equated. In the Information Processing Test, no statistically significant difference was found. Here, however, one was present. It will be remembered that when ambiguity was introduced into the information processing situation, significant differences did result. It seems, therefore, that many Ss in the concept attainment tasks were not seeing the definitive nature of the stimulus presentation in a nonexemplar situation, i. e., it appears that the situation may have been ambiguous for them. This ambiguity may have resulted because Ss perceived the relationship of inter-card differences to the delineation of a concept less efficiently than they did inter-card commonality. Instructional procedures can be developed to clarify for each S the ambiguity of the nonexemplar situation and also the indeterminant situation in information processing. It seems likely that much could be learned about instructions for specific academic subjects by carefully examining the effects of a variety of instructions on fabricated materials as were used in the concept attainment tasks of this study. This should be especially true for subject (curricular) areas highly related to the specific concept attainment task used. This would provide for researchers the rigorous experimental control which is often lacking in curricular research. To this end the factor analytic part of this study has significance.

Other Variables. Certain other effects were incidentally examined in the analyses performed in the data for this study. Specifically, it was shown that learning improved across ordinal positions in the study. This is in agreement with the findings of Byers (1961), Klausmeier *et al.* (1964), Tagatz (1963), and Meinke (1966). It is interesting to note that the largest improvement occurred between Problem II and Problem III. This concurs precisely with the findings of Meinke (1966). An additional significant effect in the present study was the difference between problems. Two problems had been used and each one presented through an exemplar and a nonexemplar mode. This finding is incidental to the major purposes of the study. However, it might be explained through the results of the study by Archer (1962). He found that there was an interaction between the obviousness and relevance of stimulus materials, such that *Ss'* performance was facilitated on tasks in which the obviousness of the relevant information is maximized and the obviousness of the irrelevant information is minimized. In the present study, the dimensions relevant to the two problems may have been more or less obvious to the *Ss*. The exact nature of this finding remains to be clarified in future research.

The factor analytic section of the investigation was concerned with the remaining two questions under consideration in the study:

3. What are the common factors that account for the relationships among the concept attainment tasks and curricular achievement tests?

4. What are the relationships among laboratory variables and the curricular areas as determined by the oblique relationships of the common (task and curricular) factors?

Alpha Factor Analyses. An intriguing result of the investigation was seen in the structure of the Alpha Factors. The Alpha Factor Analyses of the matrices, arranged by (a) type of informational presentation and (b) response option, both included the same 16 achievement tests. It was expected that they would produce the same curricular factors. Paradoxically, the matrix which included the achievement tests, the concept attainment tests, and the information processing tests arranged by type of informational presentation produced a General Achievement Factor with language arts tests showing the highest loadings and mathematics the lowest. When the six Information Processing Tests, arranged by response options, were added to the 16 achievement tests, and this 22 x 22 matrix factored, a simple Language Arts Factor was identified plus a second factor with mathematics materials and information processing showing high loadings. The change in factor structure was attributed to the similarities in the convergent reasoning common to the mathematics achievement and the Information Processing Tests arranged by response option.

Inductive reasoning was required by these two types of tests--mathematics and information processing arranged by response option. It resulted in the covariation among tests necessary to create the new Information Processing--Mathematics Factor. This explanation of the changing factor structure was supported by the high relationships between Information Processing Response Option--"Yes" Factor and two Mathematics Factors extracted in the Incomplete Image solution. Lemke (1965) has previously shown a high degree of relationship between concept attainment and an Inductive Reasoning Factor.

The two Alpha Factor Analyses also identified several factors with largest loadings on Information Processing and Concept Attainment Tests. Specifically, in information processing the following factors were identified: (a) a "No-Can't Tell" Factor, (b) an Information Processing--Arithmetic Factor, (c) an Information Processing of Presented Information Factor, and (d) two Concept Attainment Factors.

An examination of Alpha Factor intercorrelations indicated that the single achievement factor--the General Achievement Factor from the 24 x 24 matrix; the Language Arts Factor from the 22 x 22 matrix--correlated .60, .65, and .73 with (a) an Information Processing of Presented Information Factor, (b) a Concept Attainment (II) Factor, and (c) an Information Processing of Response Options--Arithmetic Factor, respectively. Two remaining factors, Concept Attainment (I) and Information Processing of "No-Can't Tell" Responses, correlated .18 and .01 with the achievement factors in the two analyses, respectively. From this examination of factors resulting from the Alpha solution, it was concluded that there is a significant positive relationship between (a) curricular areas and (b) conceptual and information processing behavior involving exemplar information.

Relatively independent of these relationships are the Information Processing of "No-Can't Tell" Response Factor and the Concept Attainment (I) Factor. This suggests that perhaps there are two distinct behavioral typologies, namely, (a) Ss who are most efficient when they focus attention on what the concept is and (b) Ss who are most efficient when they delineate the concept by analytically determining how a nonexemplar differs from an exemplar. Loadings on the bi-polar factor--Information Processing: "No-Can't Tell"--suggests the correctness of the interpretation as do the loadings on the Information Processing of Response Options-Arithmetic Factor. A person of the first typology has a tendency to specify all cards which are not exemplars as being nonexemplars. He would get disproportionately high scores on items with "No" answers and low scores on items with "Can't Tell" answers, hence the bi-polarity. A posteriori examination of the raw scores from the Information Processing Test and the matrix of intercorrelations for the Information Processing Subtests supports this conclusion.

On the other hand, people who use the analytic approach would have a tendency to do equally well on all three information processing items according to response options. This analytic typology would result in uni-dimensional loadings on tests of information processing according to to response options. The Information Processing of Response Options-Arithmetic Factor reveals precisely this arrangement of factor loadings. Additionally, certain arithmetic tests have high loadings on this factor, thereby further delineating its nature.

While this factor appears relatively independent of traditional concept attainment tasks and curricular areas other than arithmetic, the results do tie in nicely with the explanation of the contradictory findings regarding exemplars and nonexemplars in the information processing analysis and the concept attainment analysis, namely: many Ss when left on their own as they are in concept attainment do not see the definite nature of exemplar-nonexemplar stimulus presentation. This is because they are examining the commonalities among exemplars instead of analytically examining intercard differences.

Out of this milieu a question becomes apparent and remains unanswered: Can students' learning of concepts in any curricular area other than and including arithmetic be facilitated by training in the acquisition of information from simultaneous exemplar-nonexemplar stimulus presentation?

The answer to still another question might prove to be enlightening: Is it possible to structure curricular areas in such a way as to require processing of nonexemplar information? Such restructuring would allow the validation of the two hypothesized behavioral typologies. This validation would provide impetus for the determination of new teaching methods to provide adequately for the education of such Ss.

Incomplete Image Analysis. The Incomplete Image Analysis, undertaken to break down the achievement factors isolated in the Alpha solution, identified the following curricular factors (see Tables 22 and 24): (a) Mathematics (Factor VI, Table 22; Factor IX, Table 24), (b) Spelling (Factor II, Table 22; Factor XI, Table 24), (c) Reading (Factor III, Table 22; Factor IV, Table 24), (d) Science (Factor V, Table 22; Factor VI, Table 24), (e) Mathematics (Factor I, Table 22). No Social Studies

Factor was identified. This is because of the large involvement of other curricular areas in social studies activities, i.e., there was a lack of variance specific to social studies material. Additionally, the two analyses resulted in a change in the Mathematics Factor structure between the two matrices, as occurred in the Achievement Factor in the previous Alpha Factor Analyses. It resulted in the establishment of the Mathematics I Factor (Table 23) which was not common to both analyses. Table 23 indicated that the correlation between these factors was .90. Thus an extremely high relationship exists between the ,

The Incomplete Image Analyses also produced the following six non-curricular factors: (a) Nonexemplar Information Processing, (b) Exemplar Information Processing, (c) Concept Attainment of Exemplar Information, (d) Response Option--Can't Tell, (e) Response Option--Yes, and (f) Response Option--No.

From the interrelationships of the factors resulting from the Incomplete Image Analysis it is concluded that the Exemplar Information Process--"Yes" Response Option Factor correlates highly with all curricular factors. Lesser relationship existed among the Curricular Factors and (a) the Nonexemplar Information Processing Factor, (b) the Response Option--"No" Factor and (c) the Response Option--"Can't Tell" Factor. It is concluded that there is a high relationship between exemplar concept learning tasks and curricular areas but only moderate relationships between concept learning involving nonexemplars and curricular areas--and even then only certain subjects, namely science and spelling.

The purpose of the factor-analytic approach was to determine the relationships among information processing tasks, concept attainment tasks, and curricular areas. From their results it is concluded that information processing of exemplar information is moderately related to curricular factors. It is further concluded that there is a relatively high relationship between information processing of response options and certain arithmetic tests. Other specific information processing factors are moderately related to curricular achievement, namely, science and spelling. The relationship between more traditional concept attainment factors and curricular factors resulted in the conclusion that there is a high relationship between exemplar concept learning and the curricular factors generally. Thus, the findings from the factor analyses lead to the conclusion that success in concept attainment tasks is related to success in curricular areas. More liberal generalizations of research results from tightly controlled experimental settings to conventional learning situations seem justified.

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APPENDIX I

Directions for Information Processing Problems

This experiment is concerned with how people learn. You are going to have an opportunity to work several exercises.

The exercises will be performed using pictures of various cards from the board located in front of you. The board contains 64 cards.

Every card on the board is different from every other card. However, all cards have six basic properties or parts; these are:

1. Border number
2. Border type
3. Figure number
4. Figure size
5. Figure color
6. Figure shape

1. Note that all cards have either one or two borders.

(The figural cards have been either omitted or semantically presented in this Appendix.)

2. Also note that the borders are either solid or broken.

3. On the lower left of each card is located a figure. Each card will have <u>one or two</u> of these figures. (Figural materials are semantically presented.)

| | |
|---|---|
| Border Number: | One |
| Border Type: | Broken |
| Figure Number: | One |
| Figure Size: | Large |
| Figure Color: | Green |
| Figure Shape: | Circular |

| | |
|---|---|
| Border Number: | One |
| Border Type: | Broken |
| Figure Number: | Two |
| Figure Size: | Large |
| Figure Color: | Green |
| Figure Shape: | Circular |

Note that on the previous example a circle was used to illustrate one or two figures.

4. Another property, figure shape, involves <u>circular or elliptical</u> figures.

| | |
|---|---|
| Border Number: | One |
| Border Type: | Broken |
| Figure Number: | Two |
| Figure Size: | Large |
| Figure Color: | Green |
| Figure Shape: | Circular |

| | |
|---|---|
| Border Number: | One |
| Border Type: | Broken |
| Figure Number: | Two |
| Figure Size: | Large |
| Figure Color: | Green |
| Figure Shape: | Elliptical |

5. Note that these circular or elliptical figures can be small or large.

Border Number: One
Border Type: Broken
Figure Number: Two
Figure Size: Small
Figure Color: Green
Figure Shape: Circular

Border Number: One
Border Type: Broken
Figure Number: Two
Figure Size: Large
Figure Color: Green
Figure Shape: Circular

6. The figures, in addition to being one or two, large or small, circular or elliptical can be red or green.

Border Number: One
Border Type: Broken
Figure Number: Two
Figure Size: Large
Figure Color: Red
Figure Shape: Elliptical

Border Number: One
Border Type: Broken
Figure Number: Two
Figure Size: Large
Figure Color: Green
Figure Shape: Elliptical

These are the six properties making up each card. The first two properties deal with the border. That is, all cards have one or two, borders which are solid or broken. The last four properties deal with the figures. They may be red or green, small or large, circular or elliptical, and there may be one or two.

Every card on the board is different from every other card in at least one of the ways just described. As an example, consider these two cards. The first card may be described as one solid border with one large red elliptical figure.

| | |
|---|---|
| Border Number: | One |
| Border Type: | Solid |
| Figure Number: | One |
| Figure Size | Large |
| Figure Color: | Red |
| Figure Shape: | Elliptical |

The second card is described as two solid borders with one large green elliptical figure. The two cards are different in the two properties,

| | |
|---|---|
| Border Number: | Two |
| Border Type: | Solid |
| Figure Number: | One |
| Figure Size: | Large |
| Figure Color: | Green |
| Figure Shape: | Elliptical |

border number and figure color. They are the same in the other ways. Consider the following card.

| | |
|---|---|
| Border Number: | Two |
| Border Type: | Broken |
| Figure Number: | Two |
| Figure Size: | Small |
| Figure Color: | Red |
| Figure Shape: | Elliptical |

Describe the card in terms of the six properties just described. You should have described this card as having two broken borders with two small red elliptical figures.

There are a number of ways certain cards may be grouped so that the group has one or more of the same properites. As an example, consider the following three cards.

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | Two | Border Number: | One |
| Border Type: | Solid | Border Type: | Solid | Border Type: | Broken |
| Figure Number: | Two | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Large | Figure Size: | Small | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Circular | Figure Shape: | Ellip. |

These three cards can be grouped together on the basis that all three have two red figures. They are different in border number, border type, figure shape, and figure size.

Similarly the following figures

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | Two | Border Number: | Two | Border Number: | Two |
| Border Type: | Solid | Border Type: | Broken | Border Type: | Solid |
| Figure Number: | Two | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Small | Figure Size: | Small | Figure Size: | Large |
| Figure Color: | Green | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Ellip. | Figure Shape: | Ellip. |

can be grouped together on the basis that all three have two borders with two elliptical figures.

You determine the rule for grouping the following cards.

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | Two | Border Number: | Two |
| Border Type: | Solid | Border Type: | Broken | Border Type: | Solid |
| Figure Number: | One | Figure Number: | One | Figure Number: | Two |
| Figure Size: | Small | Figure Size: | Small | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Ellip. | Figure Shape: | Circ. |

You should have decided that the rule for grouping these cards was "small red figures." The term "figure(s)" means that there may be either one or two figures.

We shall now define what we mean by a rule for this task. A rule is simply one or a combination of more than one of the six properties with which we describe each card. Thus, the rule for the preceding three cards was "small red figure(s)".

Which of the following cards illustrate the rule, "one border with red elliptical figure(s)"? Note again that "figure(s)" can mean one or two figures.

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | One | Border Number: | Two |
| Border Type: | Solid | Border Type: | Broken | Border Type: | Solid |
| Figure Number: | One | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Large | Figure Size: | Small | Figure Size: | Large |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Ellip. | Figure Shape: | Ellip. | Figure Shape: | Ellip. |

You should have identified the first two cards as belonging to the group, "one border with red elliptical figure(s)," and the last card as not belonging to the group. Cards which illustrate a particular rule are called "yes" cards, and cards which do not illustrate that particular rule are called "no" cards. A "yes" card belongs to a particular group, a "no" card does not belong to that particular group. In terms of the rule "one border with red elliptical figures," the first two cards above are "yes" cards and the last is a "no" card.

In this first task you will be shown a slide with three cards as is now on the screen. The focus card is an example of a rule. Note that the card in the upper right hand corner is a "yes" card, which tells you that it also is an example of the same rule. On the other hand, a "no" card is not an example of the rule. In this task you will make a decision about the membership of the lower card, marked with a question mark. You will make this decision on the basis of the information presented in the two upper cards. Take a moment and decide if the "?" card on the screen:

(a) belongs with the focus card.

(b) does not belong with the focus card.

(c) can't tell if it belongs with the focus card.

You should have checked option "c" because you have no information about figure size. The rule might have been one broken border with large figures, or simply one broken border.

Before leaving this example, pay particular attention to the difference between small and large figures so that you can distinguish between them.

Consider another xample:

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | Two | Border Number: | Two | Border Number: | Two |
| Border Type: | Solid | Border Type: | Solid | Border Type: | Solid |
| Figure Number: | One | Figure Number: | Two | Figure Number: | One |
| Figure Size: | Large | Figure Size: | Small | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Green | Figure Color: | Red |
| Figure Shape: | Ellip. | Figure Shape: | Ellip. | Figure Shape: | Ellip. |
| Focus Card | | Yes | | ? | |

The focus card is defined as two solid borders with one large red elliptical figure. The yes card tells you that size, color and number of figures are not part of the rule. From this information you should be able to determine that the third card (?) must illustrate the rule because size doesn't matter. The question card (?) is a "yes" card.

Consider another example

| Focus Card | | No | | ? | |
|---|---|---|---|---|---|
| Border Number: | Two | Border Number: | Two | Border Number: | Two |
| Border Type: | Broken | Border Type: | Broken | Border Type: | Broken |
| Figure Number: | One | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Large | Figure Size: | Large | Figure Size: | Large |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Ellip. | Figure Shape: | Ellip. | Figure Shape: | Circ. |

In this example the second card differs from the focus card only in number of figures. The rule for grouping the yes cards must include "one figure." The (?) card has two figures. Therefore, it can't belong to the group specified by the rule. The question card (?) is a "no" card.

Consider another example

| Focus Card | | No | | ? | |
|---|---|---|---|---|---|
| Border Number: | Two | Border Number: | Two | Border Number: | Two |
| Border Type: | Broken | Border Type: | Broken | Border Type: | Broken |
| Figure Number: | One | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Large | Figure Size: | Large | Figure Size: | Large |
| Figure Color: | Red | Figure Color: | Green | Figure Color: | Red |
| Figure Shape: | Ellip. | Figure Shape: | Ellip. | Figure Shape: | Ellip. |

In this example the "focus card" and "no" card do not give you enough information to decide if the third card (?) belongs to the rule because you cannot tell whether number of figures, or figure color is part of the rule. The question (?) card in this example is a "can't tell" card. The answer sheet for the first task is on the following page. If the question card is a "yes" card, blacken the first blank. If the question card is a "no" card, blacken the second blank. If enough information isn't presented to determine the membership of the question card, blacken the third blank.

In this first series there are 30 slides. Now turn to the next page which is your answer sheet, and mark the appropriate blank as each slide is presented. (In this report the IBM 1230 Answer Sheets have been omitted.)

Task 2 is similar to the one just completed, except that you will be given four cards arranged in the following manner.

| | | | |
|---|---|---|---|
| Border Number: | Two | Border Number: | One |
| Border Type: | Solid | Border Type: | Broken |
| Figure Number: | One | Figure Number: | Two |
| Figure Size: | Small | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Green |
| Figure Shape: | Elliptical | Figure Shape: | Circular |
| Focus Card | | Yes | |

| | | | |
|---|---|---|---|
| Border Number: | Two | Border Number: | Two |
| Border Type: | Solid | Border Type: | Broken |
| Figure Number: | One | Figure Number: | Two |
| Figure Size: | Large | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Green |
| Figure Shape: | Elliptical | Figure Shape: | Elliptical |
| No | | ? | |

From the focus card and the two information cards you can determine that the card in question (?) belongs to the rule. The difference in this task is the amount of information with which you will be dealing.

Look for a moment at the screen and you will see an example of the typical task. The "yes" cards give information about the number of borders, type of borders, color of figures, number of figures, and size of figure. Your answer to the slide should be "yes."

The answer sheet for Task 2 is on the following page. Blacken either a, b, or c as before. Do you have any questions about this task? (In this report the IBM 1230 Answer Sheets have been omitted.)

## APPENDIX II

### Directions for Total Concept Attainment Task

You are about to begin an exercise like the learning task in which you have previously participated.

Before describing the task, let us review for a moment some information about the materials. Recall that the board contains 64 cards. Each card has either one or two borders.

The borders are solid or broken.

The cards also have one or two figures.

The figures are red or green.

Note also that the figures are small or large

and that the figures may be circular or elliptical in shape.

As an example consider the following card.

(The figural cards have been either omitted or semantically presented in this Appendix.)

The card can be described as two broken borders with two large green elliptical figures. The six characteristics of the card are as follows:

| | | | |
|---|---|---|---|
| Border Number: | Two | Figure Size: | Large |
| Border Type: | Broken | Figure Color: | Green |
| Figure Number: | Two | Figure Shape: | Elliptical |

Recall further that there are a number of ways certain cards may be grouped so that all cards belonging to the group share one or more of the same characteristics. As an example, consider the following three cards.

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | Two | Border Number: | One |
| Border Type: | Solid | Border Type: | Solid | Border Type: | Broken |
| Figure Number: | Two | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Large | Figure Size: | Small | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Circular | Figure Shape: | Ellip. |
| Focus Card | | Yes | | Yes | |

These three cards can be grouped together on the basis that all three have two red figures. They are different in border number, border type, figure shape and figure size.

Similarly the following figures

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | Two | Border Number: | Two | Border Number: | Two |
| Border Type: | Solid | Border Type: | Broken | Border Type: | Solid |
| Figure Number: | Two | Figure Number: | Two | Figure Number: | Two |
| Figure Size: | Small | Figure Size: | Small | Figure Size: | Large |
| FigureColor: | Green | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Ellip. | Figure Shape: | Ellip. |

can be grouped together on the basis that all three have two borders with two elliptical figures.

You determine the rule for grouping the following cards.

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | Two | Border Number: | Two |
| Border Type: | Solid | Border Type: | Broken | Border Type: | Solid |
| Figure Number: | One | Figure Number: | One | Figure Number: | Two |
| Figure Size: | Small | Figure Size: | Small | Figure Size: | Small |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Ellip. | Figure Shape: | Circu. |
| Focus Card | | Yes | | Yes | |

You should have decided that the rule for grouping these cards was "small red figures."

When you are given a "focus card" and several "no" cards, it is also possible for you to determine the rule. Consider the following example:

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | One | Border Number: | One |
| Border Type: | Broken | Border Type: | Broken | Border Type: | Broken |
| Figure Number: | Two | Figure Number: | Two | Figure Number: | One |
| Figure Size: | Large | Figure Size: | Large | Figure Size: | Large |
| Figure Color: | Green | Figure Color: | Green | Figure Color: | Green |
| Figure Shape: | Circular | Figure Shape: | Ellip. | Figure Shape: | Circu. |
| Focus Card | | No | | No | |

Each "no" card differs from the "focus card" in only one way. The fact that the middle card has elliptical figures should tell you that the rule must include "circular figures." The "no" card on the right contains only one figure. This tells you that the rule must include "two figures." From the presentation of the three cards, you would be correct in concluding that the rule was "two circular figures."

You determine the rule for the following three cards.

| | | | | | |
|---|---|---|---|---|---|
| Border Number: | One | Border Number: | One | Border Number: | One |
| Border Type: | Solid | Border Type: | Solid | Border Type: | Solid |
| Figure Number: | One | Figure Number: | One | Figure Number: | One |
| Figure Size: | Small | Figure Size: | Small | Figure Size: | Large |
| Figure Color: | Red | Figure Color: | Red | Figure Color: | Red |
| Figure Shape: | Elliptical | Figure Shape: | Circular | Figure Shape: | Ellip. |
| Focus Card | | No | | No | |

In this experiment your job is to determine a rule that I have in mind. That is, I might be thinking about a rule like "two figures." Your job is to find out what this rule is from the arrangement of "yes" and "no" markers that I will place on cards that do illustrate and do not illustrate the particular rule I have in mind. By examining which cards do and do not belong, you can find out what the rule is. When you think you know the rule, I want you to tell me. There is a special form for this purpose. Suppose the rule was "two broken borders with small circle(s)." It would be marked in the following manner:

| | | | | | |
|---|---|---|---|---|---|
| 1. Border Number | one | ( ) | two | (X) |
| 2. Border Type | solid | ( ) | broken | (X) |
| 3. Figure Number | one | ( ) | two | ( ) |
| 4. Figure Size | large | ( ) | small | (X) |
| 5. Figure Color | red | ( ) | green | ( ) |
| 6. Figure Shape | circle | (X) | ellipse | ( ) |

Whenever you think you know the rule, check the rule on the slip and give it to me. I will read it back to you so there is no misunderstanding. If your rule is correct the task is completed. If it is not correct, I shall say "not correct" and you will continue examining the board until you again think you know the rule. You may present as many rules as you like. The job is to find out the rule as quickly and with as few attempts as possible. Are there any questions?

## APPENDIX III

Data Summary Sheet

Subject Number ____________

Level ____________ Sex ______ Treatment ______

| Concept | Time | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | | |
| 12. | | |
| 13. | | |
| 14. | | |
| 15. | | |

## APPENDIX IV

### Total Matrix of Intercorrelation of Test Scores

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. Subtest #1 - Presentation of Exemplar | 1.00 | .42 | .59 | .51 | .82 | .16 | .59 |
| 2. Subtest #1 - Presentation of Nonexemplar | | 1.00 | .33 | .45 | .31 | .78 | .40 |
| 3. Subtest #2 - Presentation of Exemplar | | | 1.00 | .31 | .43 | .09 | .44 |
| 4. Subtest #2 - Presentation of Nonexemplar | | | | 1.00 | .49 | .38 | .14 |
| 5. Subtest #1 - Response "Yes" | | | | | 1.00 | .21 | .24 |
| 6. Subtest #1 - Response "No" | | | | | | 1.00 | -.12 |
| 7. Subtest #1 - Response "Can't Tell" | | | | | | | 1.00 |
| 8. Subtest #2 - Response "Yes" | | | | | | | |
| 9. Subtest #2 - Response "No" | | | | | | | |
| 10. Subtest #2 - Response "Can't Tell" | | | | | | | |
| 11. Exemplar Problem One | | | | | | | |
| 12. Exemplar Problem Two | | | | | | | |
| 13. Nonexemplar Problem One | | | | | | | |
| 14. Nonexemplar Problem Two | | | | | | | |
| 15. SRA - Arithmetic Reasoning | | | | | | | |
| 16. SRA - Arithmetic Computation | | | | | | | |
| 17. Stanford - Arithmetic Computation | | | | | | | |
| 18. Stanford - Arithmetic Application | | | | | | | |
| 19. California -Arithmetic Reasoning | | | | | | | |
| 20. STEP - Math I | | | | | | | |
| 21. Stanford - Arithmetic Concepts | | | | | | | |
| 22. California - Arithmetic Fundamentals | | | | | | | |
| 23. STEP - Math II | | | | | | | |
| 24. SRA - Arithmetic Concepts | | | | | | | |
| 25. California - Reading Vocabulary | | | | | | | |
| 26. SRA - Reading Vocabulary | | | | | | | |
| 27. Stanford - Spelling | | | | | | | |
| 28. California - Spelling | | | | | | | |
| 29. SRA - Language Arts III (Sp) | | | | | | | |
| 30. Stanford - Paragraph Meaning | | | | | | | |
| 31. California - Reading Comprehension | | | | | | | |
| 32. SRA - Reading Comprehension | | | | | | | |
| 33. SRA - Language Arts (grammar) I | | | | | | | |
| 34. California - Mechanics of English | | | | | | | |
| 35. Stanford - Language | | | | | | | |
| 36. SRA - Language Arts (grammar)II | | | | | | | |
| 37. Stanford - Social Studies | | | | | | | |
| 38. SRA - References | | | | | | | |
| 39. SRA - Charts | | | | | | | |
| 40. STEP - Social Studies I | | | | | | | |
| 41. STEP - Social Studies II | | | | | | | |
| 42. Stanford - Science | | | | | | | |
| 43. STEP - Science I | | | | | | | |
| 44. STEP - Science II | | | | | | | |
| 45. Hypothesis/$OP_1$ | | | | | | | |
| 46. Hypothesis/$OP_2$ | | | | | | | |
| 47. Hypothesis/$OP_3$ | | | | | | | |
| 48. Hypothesis/$OP_4$ | | | | | | | |
| 49. Time/$OP_1$ | | | | | | | |
| 50. Time/$OP_2$ | | | | | | | |
| 51. Time/$OP_3$ | | | | | | | |
| 52. Time/$OP_4$ | | | | | | | |

(Table continued on next page)

Table IV continued

| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | .44 | .27 | .52 | -.24 | -.09 | -.03 | -.13 | .36 | .34 | .25 | .44 | .46 | .37 | .42 | .25 |
| 2. | .16 | .29 | .30 | -.24 | .00 | -.18 | -.15 | .27 | .26 | .15 | .27 | .26 | .31 | .21 | .26 |
| 3. | .83 | .14 | .49 | -.15 | -.17 | -.09 | -.00 | .34 | .29 | .27 | .43 | .45 | .26 | .35 | .30 |
| 4. | .23 | .82 | .30 | -.25 | -.11 | -.15 | -.15 | .43 | .42 | .34 | .53 | .50 | .37 | .47 | .31 |
| 5. | .48 | .41 | .32 | -.30 | -.09 | -.13 | -.09 | .46 | .43 | .34 | .51 | .50 | .35 | .49 | .30 |
| 6. | .01 | .40 | .01 | -.19 | .01 | -.19 | -.10 | .14 | .15 | .08 | .17 | .13 | .18 | .08 | .17 |
| 7. | .27 | -.10 | .63 | -.11 | -.03 | .09 | -.06 | .19 | .23 | .17 | .20 | .29 | .31 | .22 | .21 |
| 8. | 1.00 | .24 | .15 | -.11 | -.22 | -.09 | .04 | .34 | .27 | .23 | .41 | .46 | .19 | .35 | .29 |
| 9. | | 1.00 | -.10 | -.21 | -.04 | -.10 | -.10 | .28 | .34 | .26 | .37 | .40 | .19 | .37 | .26 |
| 10. | | | 1.00 | -.17 | -.08 | -.08 | .01 | .33 | .29 | .31 | .34 | .31 | .38 | .29 | .24 |
| 11. | | | | 1.00 | .09 | .24 | .28 | -.40 | -.39 | -.33 | -.40 | -.48 | -.31 | -.43 | -.49 |
| 12. | | | | | 1.00 | -.04 | .14 | -.25 | -.07 | -.13 | -.20 | -.18 | -.21 | -.18 | -.02 |
| 13. | | | | | | 1.00 | -.04 | -.29 | -.16 | -.11 | -.20 | -.21 | -.20 | -.24 | -.21 |
| 14. | | | | | | | 1.00 | -.17 | -.16 | -.12 | -.11 | -.15 | -.09 | -.14 | -.10 |
| 15. | | | | | | | | 1.00 | .71 | .56 | .69 | .77 | .65 | .73 | .64 |
| 16. | | | | | | | | | 1.00 | .75 | .70 | .75 | .68 | .74 | .77 |
| 17. | | | | | | | | | | 1.00 | .62 | .63 | .69 | .70 | .67 |
| 18. | | | | | | | | | | | 1.00 | .78 | .67 | .83 | .62 |
| 19. | | | | | | | | | | | | 1.00 | .64 | .80 | .74 |
| 20. | | | | | | | | | | | | | 1.00 | .68 | .61 |
| 21. | | | | | | | | | | | | | | 1.00 | .66 |
| 22. | | | | | | | | | | | | | | | 1.00 |
| 23. | | | | | | | | | | | | | | | |
| 24. | | | | | | | | | | | | | | | |
| 25. | | | | | | | | | | | | | | | |
| 26. | | | | | | | | | | | | | | | |
| 27. | | | | | | | | | | | | | | | |
| 28. | | | | | | | | | | | | | | | |
| 29. | | | | | | | | | | | | | | | |
| 30. | | | | | | | | | | | | | | | |
| 31. | | | | | | | | | | | | | | | |
| 32. | | | | | | | | | | | | | | | |
| 33. | | | | | | | | | | | | | | | |
| 34. | | | | | | | | | | | | | | | |
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| 40. | | | | | | | | | | | | | | | |
| 41. | | | | | | | | | | | | | | | |
| 42. | | | | | | | | | | | | | | | |
| 43. | | | | | | | | | | | | | | | |
| 44. | | | | | | | | | | | | | | | |
| 45. | | | | | | | | | | | | | | | |
| 46. | | | | | | | | | | | | | | | |
| 47. | | | | | | | | | | | | | | | |
| 48. | | | | | | | | | | | | | | | |
| 49. | | | | | | | | | | | | | | | |
| 50. | | | | | | | | | | | | | | | |
| 51. | | | | | | | | | | | | | | | |
| 52. | | | | | | | | | | | | | | | |

(Table continued on next page)

Table IV continued

| | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | .41 | .46 | .41 | .35 | .28 | .29 | .27 | .41 | .42 | .40 | .20 | .36 | .35 | .32 | .46 |
| 2. | .28 | .24 | .20 | .21 | .16 | .15 | .16 | .20 | .29 | .24 | .15 | .23 | .26 | .21 | .30 |
| 3. | .30 | .41 | .33 | .24 | .20 | .19 | .20 | .38 | .43 | .30 | .24 | .35 | .33 | .28 | .37 |
| 4. | .41 | .44 | .40 | .43 | .31 | .35 | .35 | .42 | .51 | .43 | .30 | .39 | .42 | .37 | .54 |
| 5. | .41 | .48 | .51 | .43 | .37 | .36 | .33 | .47 | .47 | .44 | .29 | .43 | .43 | .37 | .50 |
| 6. | .11 | .10 | .12 | .15 | .10 | .07 | .09 | .09 | .15 | .16 | .09 | .09 | .14 | .15 | .16 |
| 7. | .29 | .25 | .15 | .16 | .13 | .17 | .14 | .21 | .24 | .22 | .10 | .23 | .23 | .16 | .27 |
| 8. | .26 | .39 | .33 | .22 | .16 | .19 | .20 | .35 | .39 | .28 | .24 | .33 | .30 | .25 | .32 |
| 9. | .19 | .32 | .34 | .32 | .19 | .32 | .26 | .33 | .38 | .30 | .28 | .32 | .30 | .31 | .40 |
| 10. | .33 | .29 | .26 | .29 | .30 | .20 | .24 | .32 | .35 | .33 | .19 | .28 | .34 | .22 | .38 |
| 11. | -.31 | -.41 | -.53 | -.31 | -.32 | -.39 | -.33 | -.38 | -.44 | -.30 | -.28 | -.44 | -.37 | -.35 | -.38 |
| 12. | -.24 | -.15 | -.16 | -.14 | -.09 | -.02 | -.08 | -.20 | -.19 | -.16 | -.13 | -.20 | -.13 | -.17 | -.15 |
| 13. | -.10 | -.27 | -.30 | -.25 | -.14 | -.14 | -.13 | -.22 | -.26 | -.13 | -.13 | -.17 | -.19 | -.17 | -.18 |
| 14. | -.15 | -.20 | -.23 | -.18 | -.08 | -.06 | -.12 | -.12 | -.17 | -.17 | -.05 | -.15 | -.14 | -.19 | -.16 |
| 15. | .63 | .77 | .68 | .71 | .56 | .54 | .62 | .70 | .78 | .71 | .58 | .68 | .69 | .67 | .67 |
| 16. | .64 | .74 | .64 | .76 | .68 | .64 | .69 | .73 | .75 | .73 | .70 | .75 | .80 | .67 | .73 |
| 17. | .64 | .58 | .53 | .67 | .70 | .60 | .64 | .68 | .65 | .64 | .65 | .66 | .76 | .60 | .61 |
| 18. | .68 | .71 | .63 | .70 | .60 | .59 | .61 | .74 | .78 | .69 | .53 | .65 | .72 | .58 | .83 |
| 19. | .66 | .81 | .73 | .67 | .58 | .59 | .59 | .72 | .82 | .69 | .55 | .70 | .71 | .63 | .73 |
| 20. | .70 | .63 | .55 | .65 | .64 | .56 | .63 | .67 | .65 | .68 | .57 | .62 | .71 | .61 | .68 |
| 21. | .68 | .75 | .69 | .75 | .65 | .63 | .64 | .79 | .82 | .69 | .54 | .75 | .79 | .61 | .81 |
| 22. | .56 | .67 | .57 | .61 | .61 | .63 | .63 | .62 | .71 | .60 | .62 | .71 | .70 | .62 | .61 |
| 23. | 1.00 | .65 | .54 | .65 | .61 | .53 | .58 | .65 | .68 | .69 | .56 | .61 | .71 | .56 | .66 |
| 24. | | 1.00 | .74 | .74 | .61 | .59 | .63 | .74 | .81 | .72 | .59 | .70 | .73 | .67 | .72 |
| 25. | | | 1.00 | .72 | .62 | .66 | .65 | .76 | .77 | .69 | .53 | .72 | .70 | .59 | .68 |
| 26. | | | | 1.00 | .69 | .69 | .76 | .85 | .80 | .87 | .66 | .73 | .82 | .68 | .76 |
| 27. | | | | | 1.00 | .79 | .83 | .75 | .69 | .67 | .66 | .75 | .84 | .60 | .68 |
| 28. | | | | | | 1.00 | .82 | .73 | .71 | .63 | .62 | .79 | .78 | .58 | .68 |
| 29. | | | | | | | 1.00 | .76 | .72 | .72 | .70 | .75 | .83 | .71 | .71 |
| 30. | | | | | | | | 1.00 | .83 | .84 | .62 | .80 | .87 | .69 | .81 |
| 31. | | | | | | | | | 1.00 | .77 | .61 | .83 | .83 | .65 | .61 |
| 32. | | | | | | | | | | 1.00 | .63 | .72 | .78 | .74 | .79 |
| 33. | | | | | | | | | | | 1.00 | .69 | .76 | .80 | .56 |
| 34. | | | | | | | | | | | | 1.00 | .86 | .66 | .72 |
| 35. | | | | | | | | | | | | | 1.00 | .73 | .79 |
| 36. | | | | | | | | | | | | | | 1.00 | .64 |
| 37. | | | | | | | | | | | | | | | 1.00 |
| 38. | | | | | | | | | | | | | | | |
| 39. | | | | | | | | | | | | | | | |
| 40. | | | | | | | | | | | | | | | |
| 41. | | | | | | | | | | | | | | | |
| 42. | | | | | | | | | | | | | | | |
| 43. | | | | | | | | | | | | | | | |
| 44. | | | | | | | | | | | | | | | |
| 45. | | | | | | | | | | | | | | | |
| 46. | | | | | | | | | | | | | | | |
| 47. | | | | | | | | | | | | | | | |
| 48. | | | | | | | | | | | | | | | |
| 49. | | | | | | | | | | | | | | | |
| 50. | | | | | | | | | | | | | | | |
| 51. | | | | | | | | | | | | | | | |
| 52. | | | | | | | | | | | | | | | |

(Table continued on next page)

Table IV continued

| | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | .41 | .40 | .42 | .44 | .43 | .40 | .43 | -.22 | -.09 | .06 | -.18 | -.21 | -.13 | .05 | -.15 |
| 2. | .28 | .27 | .27 | .19 | .28 | .30 | .28 | -.06 | -.08 | -.07 | -.21 | -.16 | -.16 | -.08 | -.17 |
| 3. | .36 | .35 | .33 | .28 | .33 | .37 | .32 | -.14 | -.07 | -.00 | .01 | -.15 | -.12 | .00 | -.08 |
| 4. | .40 | .41 | .45 | .40 | .54 | .34 | .40 | -.07 | -.10 | -.05 | -.18 | -.23 | -.15 | -.08 | -.17 |
| 5. | .47 | .45 | .48 | .48 | .49 | .42 | .45 | -.33 | -.03 | -.00 | -.18 | -.35 | -.08 | -.00 | -.12 |
| 6. | .20 | .13 | .18 | .06 | .16 | .11 | .18 | -.10 | -.05 | -.11 | -.18 | -.16 | -.10 | -.11 | -.10 |
| 7. | .23 | .27 | .23 | .28 | .18 | .27 | .23 | .03 | -.01 | .08 | -.05 | .01 | -.08 | .05 | -.07 |
| 8. | .35 | .30 | .29 | .24 | .30 | .32 | .26 | -.15 | -.01 | -.08 | .05 | -.13 | -.08 | -.06 | -.03 |
| 9. | .29 | .27 | .35 | .25 | .41 | .19 | .25 | -.07 | -.08 | -.04 | -.05 | -.18 | -.11 | -.08 | -.04 |
| 10. | .32 | .39 | .33 | .36 | .29 | .36 | .33 | -.08 | -.04 | .07 | -.14 | -.16 | -.05 | .06 | -.13 |
| 11. | -.41 | -.42 | -.30 | -.35 | -.27 | -.35 | -.28 | .29 | .20 | .02 | .24 | .47 | .41 | .18 | .43 |
| 12. | -.19 | -.22 | -.20 | -.24 | -.15 | -.22 | -.14 | .22 | .15 | .05 | .02 | .31 | .34 | .09 | .15 |
| 13. | -.18 | -.23 | -.16 | -.10 | -.17 | -.18 | -.16 | .16 | .38 | .18 | .23 | .30 | .43 | .23 | .30 |
| 14. | -.10 | -.19 | -.07 | -.10 | -.11 | -.02 | -.07 | .25 | .09 | .07 | .25 | .41 | .27 | .30 | .38 |
| 15. | .73 | .73 | .69 | .63 | .64 | .65 | .68 | -.27 | -.14 | -.11 | -.17 | -.40 | -.27 | -.16 | -.19 |
| 16. | .69 | .77 | .71 | .70 | .65 | .65 | .64 | -.17 | -.09 | -.10 | -.16 | -.26 | -.15 | -.16 | -.18 |
| 17. | .65 | .70 | .63 | .67 | .58 | .55 | .57 | -.18 | -.14 | -.08 | -.12 | -.26 | -.13 | -.04 | -.20 |
| 18. | .65 | .74 | .64 | .66 | .77 | .65 | .66 | -.14 | -.05 | -.09 | -.15 | -.31 | -.18 | -.12 | -.24 |
| 19. | .69 | .75 | .64 | .64 | .70 | .63 | .62 | -.24 | -.13 | -.09 | -.16 | -.36 | -.23 | -.11 | -.23 |
| 20. | .71 | .77 | .67 | .75 | .64 | .65 | .69 | -.18 | -.16 | -.16 | -.19 | -.26 | -.21 | -.13 | -.15 |
| 21. | .73 | .82 | .69 | .67 | .74 | .64 | .64 | -.24 | -.19 | .01 | -.18 | -.33 | -.28 | -.02 | -.29 |
| 22. | .65 | .67 | .61 | .60 | .55 | .60 | .62 | -.17 | -.18 | -.06 | -.12 | -.26 | -.22 | -.12 | -.17 |
| 23. | .63 | .71 | .68 | .71 | .68 | .63 | .65 | -.15 | -.13 | -.04 | -.27 | -.22 | -.17 | -.08 | -.25 |
| 24. | .71 | .77 | .69 | .63 | .71 | .69 | .63 | -.18 | -.13 | -.06 | -.20 | -.31 | -.26 | -.15 | -.26 |
| 25. | .74 | .70 | .62 | .62 | .66 | .67 | .56 | -.33 | -.18 | -.08 | -.21 | -.45 | -.26 | -.17 | -.27 |
| 26. | .80 | .79 | .76 | .74 | .78 | .70 | .73 | -.23 | -.17 | -.10 | -.23 | -.30 | -.19 | -.13 | -.22 |
| 27. | .71 | .68 | .62 | .65 | .63 | .61 | .60 | -.18 | -.02 | -.04 | -.16 | -.27 | -.06 | -.08 | -.17 |
| 28. | .72 | .66 | .62 | .63 | .63 | .61 | .58 | -.15 | -.07 | -.05 | -.07 | -.20 | -.10 | -.15 | -.13 |
| 29. | .81 | .70 | .66 | .66 | .64 | .69 | .65 | -.10 | -.10 | -.07 | -.11 | -.21 | -.14 | -.14 | -.14 |
| 30. | .80 | .81 | .77 | .75 | .78 | .75 | .75 | -.28 | -.17 | -.06 | -.13 | -.34 | -.22 | -.10 | -.18 |
| 31. | .81 | .81 | .78 | .66 | .78 | .71 | .69 | -.25 | -.15 | -.05 | -.11 | -.38 | -.25 | -.15 | -.19 |
| 32. | .76 | .77 | .77 | .78 | .77 | .74 | .76 | -.25 | -.07 | -.11 | -.19 | -.33 | -.08 | -.13 | -.18 |
| 33. | .69 | .61 | .60 | .63 | .57 | .59 | .58 | -.18 | -.07 | -.10 | -.12 | -.24 | -.08 | -.07 | -.15 |
| 34. | .77 | .75 | .69 | .65 | .69 | .71 | .69 | -.23 | -.18 | -.06 | -.11 | -.29 | -.24 | -.15 | -.19 |
| 35. | .81 | .81 | .77 | .77 | .75 | .72 | .71 | -.23 | -.17 | -.05 | -.18 | -.27 | -.20 | -.07 | -.23 |
| 36. | .75 | .64 | .67 | .69 | .66 | .64 | .63 | -.19 | -.12 | -.05 | -.11 | -.33 | -.20 | -.10 | -.17 |
| 37. | .74 | .79 | .70 | .74 | .85 | .67 | .72 | -.16 | -.09 | -.01 | -.18 | -.30 | -.17 | -.09 | -.25 |
| 38. | 1.00 | .80 | .76 | .71 | .75 | .73 | .68 | -.28 | -.16 | -.06 | -.18 | -.33 | -.20 | -.08 | -.19 |
| 39. | | 1.00 | .74 | .76 | .74 | .70 | .71 | -.27 | -.18 | -.04 | -.25 | -.34 | -.25 | -.12 | -.28 |
| 40. | | | 1.00 | .75 | .71 | .71 | .75 | -.26 | -.17 | -.01 | -.15 | -.32 | -.21 | -.00 | -.10 |
| 41. | | | | 1.00 | .67 | .69 | .75 | -.20 | -.07 | .00 | -.18 | -.32 | -.14 | -.02 | -.20 |
| 42. | | | | | 1.00 | .73 | .74 | -.18 | -.09 | -.05 | -.21 | -.27 | -.12 | -.06 | -.22 |
| 43. | | | | | | 1.00 | .81 | -.20 | -.15 | -.04 | -.14 | -.28 | -.20 | -.03 | -.12 |
| 44. | | | | | | | 1.00 | -.21 | -.17 | -.06 | -.21 | -.25 | -.18 | -.04 | -.12 |
| 45. | | | | | | | | 1.00 | .12 | .16 | .13 | .71 | .02 | -.00 | .06 |
| 46. | | | | | | | | | 1.00 | -.15 | .18 | -.02 | .79 | -.19 | .18 |
| 47. | | | | | | | | | | 1.00 | -.04 | .04 | -.25 | .75 | -.11 |
| 48. | | | | | | | | | | | 1.00 | .03 | .15 | -.11 | .80 |
| 49. | | | | | | | | | | | | 1.00 | .12 | .08 | .11 |
| 50. | | | | | | | | | | | | | 1.00 | -.11 | .31 |
| 51. | | | | | | | | | | | | | | 1.00 | -.05 |
| 52. | | | | | | | | | | | | | | | 1.00 |

## Appendix V

Matrix of Intercorrelation of Twenty-four Tests: Four Information Processing Tests Scored on the Basis of Stimulus Presentation, Four Concept Attain Problems, and Sixteen Achievement Tests

| | Tests | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Subtest 1 - Presentation of Exemplars | 1.00 | .42 | .59 | .51 | -.24 | .09 | -.03 | -.13 | .44 | .46 |
| 2. | Subtest 1 - Presentation of Nonexemplars | | 1.00 | .33 | .45 | -.24 | .00 | -.18 | -.15 | .27 | .28 |
| 3. | Subtest 2 - Presentation of Exemplars | | | 1.00 | .31 | -.15 | -.17 | -.09 | -.00 | .43 | .45 |
| 4. | Subtest 2 - Presentation of Nonexemplars | | | | 1.00 | -.25 | -.11 | -.15 | -.15 | .53 | .50 |
| 5. | Exemplar Problem 1 | | | | | 1.00 | .09 | .24 | .28 | -.40 | -.48 |
| 6. | Exemplar Problem 2 | | | | | | 1.00 | -.04 | .14 | -.20 | -.18 |
| 7. | Nonexemplar Problem 1 | | | | | | | 1.00 | -.04 | -.20 | -.21 |
| 8. | Nonexemplar Problem 2 | | | | | | | | 1.00 | -.11 | -.15 |
| 9. | Stanford - Arithmetic Application | | | | | | | | | 1.00 | .78 |
| 10. | California - Arithmetic Reasoning | | | | | | | | | | 1.00 |
| 11. | Stanford - Arithmetic Concepts | | | | | | | | | | |
| 12. | SRA - Arithmetic Concepts | | | | | | | | | | |
| 13. | SRA - Reading Vocabulary | | | | | | | | | | |
| 14. | Stanford - Spelling | | | | | | | | | | |
| 15. | California - Spelling | | | | | | | | | | |
| 16. | SRA - Language Arts (Spelling) | | | | | | | | | | |
| 17. | Stanford - Paragraph Meaning | | | | | | | | | | |
| 18. | SRA - Reading Comprehension | | | | | | | | | | |
| 19. | SRA - References | | | | | | | | | | |
| 20. | SRA - Charts | | | | | | | | | | |
| 21. | STEP - Social Studies 1 | | | | | | | | | | |
| 22. | Stanford - Science | | | | | | | | | | |
| 23. | STEP - Science 1 | | | | | | | | | | |
| 24. | STEP - Science 2 | | | | | | | | | | |

(continued on next page)

APPENDIX V continued

| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | .42 | .46 | .35 | .23 | .29 | .27 | .41 | .40 | .41 | .40 | .42 | .43 | .40 | .43 |
| 2. | .21 | .24 | .21 | .16 | .15 | .16 | .20 | .24 | .28 | .27 | .27 | .28 | .30 | .28 |
| 3. | .35 | .41 | .24 | .20 | .19 | .20 | .38 | .30 | .36 | .35 | .33 | .33 | .37 | .32 |
| 4. | .47 | .44 | .43 | .31 | .35 | .35 | .42 | .43 | .40 | .41 | .45 | .54 | .34 | .40 |
| 5. | -.43 | -.41 | -.31 | -.32 | -.39 | -.33 | -.38 | -.30 | -.41 | -.42 | -.30 | -.27 | -.35 | -.28 |
| 6. | -.18 | -.15 | -.14 | -.09 | -.02 | -.03 | -.20 | -.16 | -.19 | -.22 | -.20 | -.15 | -.22 | -.14 |
| 7. | -.24 | -.27 | -.25 | -.14 | -.14 | -.13 | -.22 | -.13 | -.18 | -.23 | -.16 | -.17 | -.15 | -.16 |
| 8. | -.14 | -.20 | -.18 | -.08 | -.06 | -.12 | -.12 | -.17 | -.10 | -.19 | -.07 | -.11 | -.02 | -.07 |
| 9. | .83 | .71 | .70 | .60 | .59 | .61 | .74 | .69 | .65 | .74 | .64 | .77 | .65 | .66 |
| 10. | .80 | .81 | .67 | .58 | .59 | .59 | .72 | .69 | .69 | .75 | .64 | .70 | .63 | .62 |
| 11. | 1.00 | .75 | .75 | .65. | .63 | .64 | .79 | .69 | .73 | .82 | .69 | .74 | .64 | .64 |
| 12. | | 1.00 | .74 | .61 | .59 | .63 | .74 | .72 | .71 | .77 | .69 | .71 | .69 | .63 |
| 13. | | | 1.00 | .69 | .69 | .75 | .85 | .87 | .80 | .79 | .76 | .78 | .70 | .73 |
| 14. | | | | 1.00 | .79 | .83 | .75 | .67 | .71 | .68 | .62 | .63 | .61 | .60 |
| 15. | | | | | 1.00 | .82 | .73 | .63 | .72 | .66 | .62 | .63 | .61 | .58 |
| 16. | | | | | | 1.00 | .76 | .72 | .81 | .70 | .66 | .64 | .69 | .65 |
| 17. | | | | | | | 1.00 | .84 | .80 | .81 | .77 | .78 | .75 | .75 |
| 18. | | | | | | | | 1.00 | .76 | .77 | .77 | .77 | .74 | .76 |
| 19. | | | | | | | | | 1.00 | .80 | .76 | .75 | .73. | .68 |
| 20. | | | | | | | | | | 1.00 | .74 | .71 | .70 | .71 |
| 21. | | | | | | | | | | | 1.00 | .71 | .71 | .75 |
| 22. | | | | | | | | | | | | 1.00 | .73 | .74 |
| 23. | | | | | | | | | | | | | 1.00 | .81 |
| 24. | | | | | | | | | | | | | | 1.00 |

Appendix VI

Matrix of Intercorrelation of Twenty-two Tests: Six Information Processing Tests Scored on the Basis of Response Options and Sixteen Achievement Tests

| | Tests | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Subtest 1 - Response "Yes" | 1.00 | .21 | .24 | .48 | .41 | .32 | .51 | .50 | .49 | .48 |
| 2. | Subtest 1 - Response "No" | | 1.00 | -.12 | .01 | .39 | .01 | .17 | .13 | .08 | .10 |
| 3. | Subtest 1 - Response "Can't Tell" | | | 1.00 | .27 | -.10 | .63 | .20 | .29 | .22 | .25 |
| 4. | Subtest 2 - Response "Yes" | | | | 1.00 | .24 | .15 | .41 | .46 | .35 | .39 |
| 5. | Subtest 2 - Response "No" | | | | | 1.00 | -.10 | .37 | .40 | .37 | .32 |
| 6. | Subtest 2 - Response "Can't tell" | | | | | | 1.00 | .34 | .31 | .29 | .29 |
| 7. | Stanford - Arithmetic Application | | | | | | | 1.00 | .78 | .83 | .71 |
| 8. | California - Arithmetic Reasoning | | | | | | | | 1.00 | .80 | .81 |
| 9. | Stanford - Arithmetic Concepts | | | | | | | | | 1.00 | .75 |
| 10. | SRA - Arithmetic Concepts | | | | | | | | | | 1.00 |
| 11. | SRA - Reading Vocabulary | | | | | | | | | | |
| 12. | Stanford - Spelling | | | | | | | | | | |
| 13. | California - Spelling | | | | | | | | | | |
| 14. | SRA - Language Arts (Spelling) | | | | | | | | | | |
| 15. | Stanford - Paragraph Meaning | | | | | | | | | | |
| 16. | SRA - Reading Comprehension | | | | | | | | | | |
| 17. | SRA - References | | | | | | | | | | |
| 18. | SRA - Charts | | | | | | | | | | |
| 19. | STEP - Social Studies 1 | | | | | | | | | | |
| 20. | Stanford - Science | | | | | | | | | | |
| 21. | STEP - Science 1 | | | | | | | | | | |
| 22. | STEP - Science 2 | | | | | | | | | | |

(continued on next page)

APPENDIX VI continued

| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | .43 | .37 | .36 | .33 | .47 | .44 | .47 | .45 | .48 | .49 | .42 | .45 |
| 2. | .15 | .10 | .07 | .09 | .09 | .16 | .20 | .13 | .18 | .16 | .11 | .18 |
| 3. | .16 | .13 | .17 | .14 | .21 | .22 | .23 | .27 | .23 | .18 | .27 | .23 |
| 4. | .22 | .16 | .19 | .20 | .35 | .28 | .35 | .30 | .29 | .30 | .32 | .26 |
| 5. | .32 | .19 | .32 | .26 | .33 | .30 | .29 | .27 | .35 | .41 | .19 | .25 |
| 6. | .29 | .30 | .20 | .24 | .32 | .33 | .32 | .39 | .33 | .29 | .36 | .33 |
| 7. | .70 | .60 | .59 | .61 | .74 | .69 | .65 | .74 | .64 | .77 | .65 | .66 |
| 8. | .67 | .58 | .59 | .59 | .72 | .69 | .69 | .75 | .64 | .70 | .63 | .62 |
| 9. | .75 | .65 | .63 | .64 | .79 | .69 | .73 | .82 | .69 | .74 | .64 | .64 |
| 10. | .74 | .61 | .59 | .63 | .74 | .72 | .71 | .77 | .69 | .71 | .69 | .63 |
| 11. | 1.00 | .69 | .69 | .75 | .85 | .87 | .80 | .79 | .76 | .78 | .70 | .73 |
| 12. | | 1.00 | .79 | .83 | .75 | .67 | .71 | .68 | .62 | .63 | .61 | .60 |
| 13. | | | 1.00 | .82 | .73 | .63 | .72 | .66 | .62 | .63 | .61 | .58 |
| 14. | | | | 1.00 | .76 | .72 | .81 | .70 | .66 | .64 | .69 | .65 |
| 15. | | | | | 1.00 | .84 | .80 | .81 | .77 | .78 | .75 | .75 |
| 16. | | | | | | 1.00 | .76 | .77 | .77 | .77 | .74 | .76 |
| 17. | | | | | | | 1.00 | .80 | .76 | .75 | .73 | .68 |
| 18. | | | | | | | | 1.00 | .74 | .74 | .70 | .71 |
| 19. | | | | | | | | | 1.00 | .71 | .71 | .75 |
| 20. | | | | | | | | | | 1.00 | .73 | .74 |
| 21. | | | | | | | | | | | 1.00 | .81 |
| 22. | | | | | | | | | | | | 1.00 |