THE EFFECT OF AGE, SEX, IQ, AND FUNCTIONAL GRADE LEVEL UPON THE PERFORMANCE OF SUBJECTS ON A MEASURE OF ABSTRACT LEARNING ABILITY

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ABSTRACT

The purpose of this study was to determine the effect of age, sex, IQ, and functional grade level on the classification ability of adult and non-adult subjects. The theory presented suggested that age, IQ, and functional grade level would affect classification ability whereas sex would have no effect.

The sample for testing these hypothesized relationships consisted of six groups (195 subjects); three groups of adults and three groups of non-adults categorized on the basis of their functional grade level. The non-adult subjects were selected from those subjects in attendance in educational institutions at the public school level, whereas adult subjects were chosen from adult education centers and a post-secondary institution. The age range for adult subjects was 16.5-51.1 years, with an age range of 9.4-17.6 years for non-adult subjects.

The Test of Natural Phenomena, an instrument designed to measure classification ability was administered individually to all subjects included in the study. At that time information was also obtained on the independent variables, age, sex, IQ, and functional grade level.

Regression analysis was conducted on the four predictor variables (age, sex, IQ, and functional grade level) to establish their effect on the classification ability of

adult and non-adult subjects. It was found that the four predictor variables accounted for 55% of the variance in the classification ability of adults and 33.7% for non-adults. In the case of adult subjects functional grade level, and IQ were significant whereas age and sex were insignificant. For non-adult subjects functional grade level, IQ, and age were significant but sex was insignificant. These findings supported the original hypotheses with the only exception being the finding that the predictor variable age was insignificant in the case of adult subjects.

ACKNOWLEDGEMENT

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Appreciation is expressed to the staff and students of the various educational institutions involved in this study. Their cooperation was certainly instrumental during the data collection stage.

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CHAPTER I

INTRODUCTION

The Problem

Background to the Study

Abstraction, as an important part of human learning, has been the subject of numerous investigations. However, these investigations have been quite varied in scope and therefore the findings of these investigations demonstrate little consensus as to the nature and meaning of the term. In general, investigations of abstraction fall under a variety of different topics such as discrimination learning, concept formation, or classification/categorization processes and, as such, detailed knowledge of the nature and development of abstraction is fragmented and poorly understood.[1] While many investigators would agree with this criticism few have attempted detailed and systematic studies concerning the use and meaning of the term abstraction. Clearly, if the concept of abstraction is to be meaningfully understood, systematic investigations concerning the nature and meaning of the term need to be undertaken. In addition,

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[1]Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects," (Doctoral Dissertation, Columbia University, New York, 1974), p. 2.

exploration of this particular dimension of learning is impossible without clear and precise terminology. For without a clear understanding of the term, reliable and valid measures of it can not be developed.

One viable approach in dealing with a complex phenomena such as abstract learning is through the development of theoretical models. A model consistent with prior theoretical and empirical considerations within a particular field of knowledge can serve as a useful guide for investigations. As a basic research strategy, model building is not simply an outgrowth of factual or logical considerations, nor a haphazard or random investigative strategy, but offers a valid theoretical framework from which to explore complex phenomena such as abstraction. Any model can be adopted on the basis of rational considerations as long as it is realized that other researchers could adopt alternate models or strategies. Based on this line of argument, researchers can then evaluate theoretical issues like abstraction by developing and testing pre-theoretical models. Such models would then serve as guidelines for further investigations.

The present study is an attempt to further investigate a model of abstract learning. The model under study was developed by W.E. Lowell as part of his doctoral study at Columbia University, New York.

Lowell's model of abstract learning has a strong theoretical base and is consistent with the research discussed under the term abstraction. This model is based on the following definition:

> Abstraction is a cognitive process of discriminating specific attributes of the environment that can be combined to form generalized representations which can take the form of classes, sets of relations, or operations.[2]

From the above definition it is clear that abstraction here is considered to be multi-dimensional. One dimension, classification, has been explored in two earlier studies. The results of these studies in general have supported the model and provide evidence that it is a valid indicator of cognitive ability.[3,4] However, these explorations, as preliminary studies of the model of abstraction, did not attempt a systematic investigation of the influence of how specific learner variables such as age, sex, IQ, and functional grade level influence abstract ability.[5] Since these variables have been shown to play a crucial role in abstract performances, this study will explore how these

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[2]Lowell, p. 3.

[3]Lowell, p. 57.

[4]Walter Edward Lowell, "A Study of Hierarchical Classification in Concrete and Formal Thought," (Paper presented at the annual general meeting of the National Science Teachers Association, Toronto, March 1978).

[5]See definition of variables.

variables relate to performance on an abstraction measure.

Statement of the Problem

This is an exploratory study which will systematically evaluate the influence of age, sex, IQ, and functional grade level on subjects from a variety of educational settings on a test of hierarchical classification based on one dimension of a model of abstract learning. Specifically, the study will explore and describe the limits of abstract learning in six different groups; three adult and three non-adult groups categorized on the basis of their functional grade level.

One objective of this study is to develop and quantify a statistical model of causal relations which will provide insight into the relationship of age, sex, IQ, and functional grade level on abstract learning, specifically hierarchical classification, in adult and non-adult subjects. The model of causal relations that is examined brings together a number of hypothesized relationships and incorporates them into a system of causal relations.

As a measure of one dimension of abstract learning, hierarchical classification, an instrument, the Test of Natural Phenomena, will be administered individually to each subject. This instrument has been employed in two earlier studies.[6,7] Since these studies did not attempt a detailed examination of the hypothesized relationships considered in the present investigation, this study will therefore explore how the variables, age, sex, IQ, and functional grade level relate to performance on the abstraction measure.

In addition this study will evaluate the reliability and validity of the instrument used to measure abstraction. Although the instrument has been used in two earlier studies it has undergone limited evaluation and it is therefore necessary to further examine the reliability and validity of the Test of Natural Phenomena. By exploring a larger sample of subjects from a variety of educational settings this study will provide a broader data base for the establishment of instrument reliability. It will also allow for the comparison of the performance of groups in this study with comparable groups in the two previous studies. The validity of the instrument will be examined by looking at the proportion of subjects who performed consistently on the hierarchical test (i.e., subjects failing the lower levels of hierarchy should continue to fail higher levels).

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[6] Walter Edward Lowell, "An Empirical Study of a Model of Abstract Learning," Science Education, LXI, No. 2 (1977), 229-242.

[7] Walter Edward Lowell, "A Study of Hierarchical Classification in Concrete and Formal Thought," (Paper presented at the annual general meeting of the National Science Teachers Association, Toronto, March 1978).

Definitions

The groups referred to in this study will consist of adult and non-adult subjects. The non-adult subjects are subjects who are in attendance in an educational institution at the public school level, whereas adult subjects are in attendance at educational institutions other than the regular public school system. In this case adult subjects will be chosen from a post-secondary institution and two adult education centers which offer educational programs in primary-high school education. Sixteen years is the minimum age requirement for entrance into such programs.

Functional grade level will be used to define group membership in both adult and non-adult groups. The reason for defining group membership on this basis is that this study deals with subjects from a variety of educational institutions which use different methods to define a subject's educational level. The functional grade level of subjects in this study was therefore determined by the following criteria:

EITHER

A. Grade level as determined by a reading test

AND/OR

B. (1) Teacher-school grade placement as determined by subject marks. Student must have received a school average of at least 60% at mid-year.

B. (2) Student must also be reading at grade level as judged by teachers.

Criteria A and B were used to select all subjects except those adults in Groups 1 and 2 where only criteria A was used.

Hypotheses

The hypotheses for the study are outgrowths of statement of the problem and are supported by the related research which will be presented in Chapter II.

Hypothesis 1A: The age of an adult or non-adult subject will affect his performance on the test of abstract learning ability. Older subjects will perform better than younger subjects.

Hypothesis 1B: The performance of adult subjects will be superior to that of non-adult subjects.

Hypothesis 2: The sex of an adult or non-adult subject will not affect the subject's performance on the test of abstract learning ability.

Hypothesis 3: The performance of adult or non-adult subjects of high IQ will be superior to those of low IQ on the test of abstract learning ability.

Hypothesis 4: The higher the functional grade level of the adult or non-adult subject the better the performance of that subject on the test of abstract learning ability.

Significance of the Study

Most researchers in the area of human learning acknowledge that there are many misconceptions concerning the term abstraction.[8] Welch, and Long were among the first to recognize this problem.[9,10] They initiated one of the first systematic attempts to study abstraction. As a result of their work in this area, they developed a hierarchy of abstractness by which concepts could be defined. Although their work offered a viable approach to the subject, abstraction was not Welch's immediate subject of research. In fact, it is only in recent years that abstraction has become the object of concern in a large volume of research. The findings of such research, however, indicate that there are many disparities in the uses of the term abstraction.

In response to the above situation Lowell developed a model of abstraction as a theoretical framework for the exploration of abstraction. The model of abstraction developed by Lowell is accountable to the variety and the

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[8]Edgar W. Vinacke, "The Investigation of Concept Formation," Psychological Bulletin, XLVIII, No. 1 (1951), 1-8.

[9]L. Welch, "The Genetic Development of the Associational Structures of Abstract Thinking," Journal of Genetic Psychology, LVI, No. 2 (1940), 175-206.

[10]L. Welch, and L. Long, "The Higher Structural Phases of Concept Formation of Children," Journal of Psychology, IX, No. 1 (1940), 59-95.

scope of the research on the subject of abstraction. Moreover, Lowell's model of abstraction has allowed for the development of a measure which enables direct comparison of the abstract learning ability of various groups. In fact, a number of studies conducted on one dimension of the model--hierarchical classification--have dealt with the comparison of performance of school age children on the abstraction measure. While these studies offer a somewhat more systematic approach for the investigation of abstraction, as preliminary studies of the model no attempt has been undertaken to conduct analyses of specific factors that influence performance on this particular dimension of the model. Therefore, if relationships can be established between age, sex, IQ, functional grade level, and abstract learning ability, as measured by the instruments as used in this study, a more accurate and reliable comparison of abstract ability can be achieved. It is for this reason that the present study has theoretical and practical significance. Furthermore, if a prediction equation which establishes the effect of age, sex, IQ, and functional grade level on the abstraction measure is formulated, educators can then judge more accurately the importance of these variables in influencing abstract ability in human cognition. Such knowledge would help educators develop materials and objectives to better cope with teaching classification processes to adult and non-adult subjects.

The exploration of abstract learning abilities in adult groups is of particular significance because so few studies have explored the cognitive abilities of adult populations.[11] Much of what is known about the cognitive ability of adults has been generalized from studies conducted on children. Numerous references to this issue are cited in the literature on adult education.[12]

Since a limited number of studies have been conducted on the model of abstraction under study, this investigation will provide further data on the reliability and validity of the model, thus providing a more refined assessment of the model and its significance in describing human cognitive behavior.

Limitations of the Study

This study only considered a limited number of variables (age, sex, IQ, and functional grade level) as having influence on abstract learning. The limited number of variables considered can not account for the total variance in subject performance. Since it is impossible to account for all of the variance other significant variables may exist that were not considered here.

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[11]Angelica W. Cass, Basic Education for Adults (New York: Association Press, 1971), pp. 29-30.

[12]Cass, pp. 29-30.

One limitation of this study was created by the sampling method. In an attempt to control variables the sampling of the adult population in this study was restricted to adults enrolled in educational institutions. As a result, the findings of this study might not be generalizable to the adult population as a whole but only to those adults enrolled in similar educational institutions since adults who were enrolled in educational institutions may have characteristics which are different from those who do not enroll in such programs.

Another question on the generalizability of results arises due to the small number of subjects enrolled in the Basic Literacy and Basic Training in Skills Development Programs, thus prohibiting random selection of subjects. In addition, the nature of the design of this study provided some subject variables which were not equatable. One such variable was functional grade level. This posed no problems with respect to the non-adult subjects because all three public school systems used in this study used the same method for determining grade placement. However, it did cause problems for adult students enrolled in the Basic Literacy and Basic Training in Skills Development Programs who are taught at a more accelerated rate than non-adult students in the public school system. That is, an adult student may complete several school grades in the one year. The investigator, therefore, defined functional grade level for these adult students by their reading level at time of testing.

The results obtained from the instrument used in this study were interpreted using the model of abstraction. Although the instrument used is logically sound, it has undergone limited exploration; the results will therefore depend on the reliability and validity of the instrument used in the study. Even though an attempt to establish reliability and validity was examined, it was not the main purpose of the study. The use of a more refined system such as Guttman Scaling seems particularly appropriate for assessing the hierarchical validity of the instrument. However, since this was not the main focus of the study such an undertaking must be left for a future study.

CHAPTER II

RELATED LITERATURE

Abstraction

Abstraction: A Problem of Definition

Abstraction has frequently been the focus of research in education and psychology. This is evidenced by the large volume of research literature devoted to the subject. This attention is the outgrowth of investigations concerning theories of intellectual development put forward by a number of psychologists. As a result, educators and psychologists argue that an understanding of the psychological dimensions of abstraction and how humans learn abstractions is essential to the understanding of human intelligence.

While researchers have acknowledged the significance of abstraction in human intelligence few are in agreement on a definition of abstraction as it relates to human learning. A review of the literature indicates that the concept abstraction is used synonymously for such terms as concept formation, discrimination learning, or classification/ categorization processes. It is thus difficult to state one specific definition that would represent a consensus of opinion concerning its meaning. While there are certain difficulties involved, for the purposes of this study, it will be assumed that the variety of terminology used to describe abstraction are synonymous with the concept abstraction. That is, they stand for the same basic cognitive process and thus will be treated as representing a common dimension of human intellectual ability. However, the purpose of this review is not to provide a detailed analysis of the ambiguities of the term since such analyses have been produced elsewhere.[13] Instead a general discussion of abstraction will be presented emphasizing the commonalty of a variety of different definitions used to represent the process of abstraction. Such a discussion will formulate the basis upon which the definition of abstraction used in this study is based.

Towards a Definition of Abstraction

Margeneau viewing abstraction from a philosophical perspective defines abstraction as:

> an elementary form of construction, and only an elementary form. An abstraction is the union of particulars into universals and occurs at all levels of a science. Construction, in addition to performing this union, endows the product with suitable properties of its own; it is a creative as well as a synthetic act.[14]

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[13] Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Ability Subjects" (Doctoral Dissertation, Columbia University, New York, 1974), pp. 1-5.

[14] Henry Margeneau, The Nature of Physical Reality (New York: McGraw-Hill Book Company, Inc., 1950), p. 71.

Margeneau clearly sees abstraction as a process by which man attempts to simplify his complex environment through the construction of concepts.

Ausubel in discussing human abstract behavior states:

> Anyone who pauses long enough to give the problem some serious thought cannot escape the conclusion that man lives in a world of objects, events, and situations. The reality he experiences psychologically is related only indirectly both to the physical properties of his environment and to their sensory correlation. Reality, figuratively speaking is experiences through a conceptual or categorical filter. That is, the cognitive content of a group of spoken or written words elicits in the recipient of a message a highly simplified, abstract, and generalized version both of the actual realities to which they refer in the physical world and of the actual conscious experiences which these realities evoke in the narrator.[15]

Although Ausubel is viewing abstraction from a psychological framework he, like Margeneau, sees abstraction as a process whereby man attempts to simplify environmental complexity by the formation of constructs or concepts.

Even though Margeneau and Ausubel have only indirectly made reference to the fact that concept formation and attainment are components of abstraction and can thus be subsumed by it, others have made more explicit reference to this relationship. Such a reference to the link between concept formation and abstraction is made by

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[15]David P. Ausubel, Educational Psychology: A Cognitive View (New York: Holt, Rinehart, and Winston, Inc., 1968), p. 505.

Vinacke who notes that there are two terms which are usually employed in explaining concept formation, (1) abstraction, and (2) generalization. He sees abstraction as the linking of one sensory experience to another, during which some details are left out and others become dominant (in this sense, the concept is a symbolic response for these dominant details). Generalization, however, signifies that the dominant detail (or group of details) resulting from abstraction is used as a basis for responding to others similarly linked.[16]

Superficially, Vinacke appears to place more emphasis on concept formation than on abstraction. However, a closer examination reveals that Vinacke, in discussing concept formation, views abstraction as a process through which concepts are formed. This view of abstraction is compatible with the position taken in this review (i.e., concept formation can be subsumed under the term abstraction).

P.J. Leagans, H.G. Copeland and G.E. Kaiser view concept formation or abstraction from a similar viewpoint as that of Vinacke. They see abstraction as:

> Mental pictures or perceptions of reality to which specialists in a discipline have assigned names and meanings. Concepts are useful in perceiving the meaning, nature, and dimensions of a phenomena, in organizing classes of objects or related facts in a form of a generalized idea, in analyzing situations, in dealing with problems; in

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[16]Edgar W. Vinacke, <u>The Psychology of Thinking</u> (New York: McGraw-Hill Company, Inc., 1952), p. 104.

> communicating ideas and information in keeping up with the knowledge explosion, and in serving as "building blocks" for developing understanding of perceived related groupings of concrete ideas or data.
> Concepts have several characteristics: they are developmental or open-ended; and they constitute abstractions which have a mental, verbal, and sometimes a physical form.[17]

Hunt notes that an understanding of human abstract cognition is essential to the understanding of human thought. He therefore proposes to operationally define abstraction as:

> The ability to apply the operation of inclusion to sets of objects defined by descriptive elements. For instance, the sets of objects "vegetable," "fluid," "meat," are all included within the set "food," with it being referred to as a higher-order abstraction.[18]

Hunt believes that to study abstracting ability it is essential to recognize its occurrence (i.e. we must be able, through the process of subject observation, to decide when a person has acquired a concept).[19] This view of abstraction is similarly held by Bourne,[20] and Welch[21] who argue that

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[17]J.P. Leagans, Harlan G. Copeland, and Gertrude E. Kaiser, Selected Concepts from Educational Psychology and Adult Education for Extension and Continuing Education (Syracuse, New York: Syracuse University Press, 1971), p. v.

[18]Earl B. Hunt, Concept Learning (New York: John Wiley and Sons, Inc., 1966), p. 167.

[19]Hunt, pp. 1-5.

[20]Lyle E. Bourne, Human Conceptual Behavior (Boston: Allyn and Bacon, Inc., 1968), pp. 2-5.

[21]Livingston Welch, "A Behaviorist Explanation of Concept Formation," The Journal of Genetic Psychology, LXXI, No. 2 (1947), 200-202.

it is essential to be able to recognize when a person has acquired a concept.

Unfortunately, disparate uses of the term abstraction have in the past made detailed analysis of the term difficult. From the above discussion it is clear that there needs to be a definition as to what specifically constitutes the process of abstraction.

Lowell, in a study of abstract learning, proposed a general definition consistent with the various processes ascribed to the term, abstraction. Lowell defines abstraction as:

> A cognitive process of discriminating specific attributes of the environment that can be combined to form generalized representations of experience. These representations can be categories, sets of relations, or operations. The ability to form categories or to classify experience is not only considered to be the most basic of the three modes of representing experience, but also fundamental to representations which involve sets of relations and operations.[22]

This definition is compatible with various uses of the term and is for the most part in agreement with the generalizations on abstraction noted by J.P. Leagans, H.G. Copeland, and G.E. Kaiser;[23] and Vinacke.[24] One point which

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[22] Walter Edward Lowell, "An Empirical Study of a Model of Abstract Learning," Science Education, LXI, No. 2 (1977), 229-230.

[23] Leagans, Copeland, and Kaiser, p. 11.

[24] Edgar W. Vinacke, "The Investigation of Concept Formation," Psychological Association, XLVIII, No. 1 (1951), 2-3.

is not clearly indicated in Lowell's definition but which is made in the above review is that the process of abstraction or concept formation is dependent on previous sensory processes (or past experiences of the organism). The investigator, therefore, proposes to expand Lowell's definition of abstraction to include this point. Abstraction will then be defined as:

> A cognitive process which is dependent upon data derived from previous sensory experience for the discrimination of specific attributes of the environment that can be combined to form generalized representations of experience. These representations can be categories, sets of relations, or operations. The ability to form categories or to classify experience is not only considered to be the most basic of the three modes of representing experience, but also fundamental to representations which involve sets of relations or operations.

Since this study is concerned with the exploration of the classification dimension of abstraction, the remaining discussion will focus on this dimension.

A Model of Abstraction

One of the first attempts at building a model of abstraction was initiated by Welch. He developed a model of hierarchical abstract concepts. The Welch model consisted of five levels, with the hierarchy proceeding from the concrete level to increasing levels of abstractness. The following concepts are presented by Welch as examples of the order of increasing abstractness:

This dog . . . collie . . . dog . . . animal . . . living substance . . . substance.

The Concept	Levels of Abstractness
substance	5th hierarchy
living substance	4th hierarchy
animal	3rd hierarchy
dog	2nd hierarchy
collie	1st hierarchy
this dog	concrete or object level

Welch used the word hierarchy to refer to each level of abstractness in his model.[25] Vinacke in his review of literature on concept formation is also in agreement with Welch's structuring of concepts.[26] Lowell's model of abstraction, which is the model that will be explored in this study, is based on a similar theoretical framework.

Lowell's model defines abstraction as consisting of an hierarchical arrangement of cognitive modes of representing experience. These modes include (1) classification, (2) relations, and (3) operations. The modes are referred to as orders of abstraction. The first order, classification, is the process of combining specific attributes to form generalizations such as an object name, or a class, or classes. The second order, relations, is the process of

[25]Welch, pp. 202-206.

[26]Vinacke, pp. 4-6.

constructing relational statements about objects or classes once they have been identified. The third order, operations, is the process of transforming units and/or relations once the units have been established. These units are then transformed into a unit or set of relations. A good example of operations would include arithmetic operations. For example, the order of operations would be used in the solution of the following mathematical problem.

> What is the cost per square foot? Given the cost of a 10 feet by 20 feet of wall-board costs $15.25.

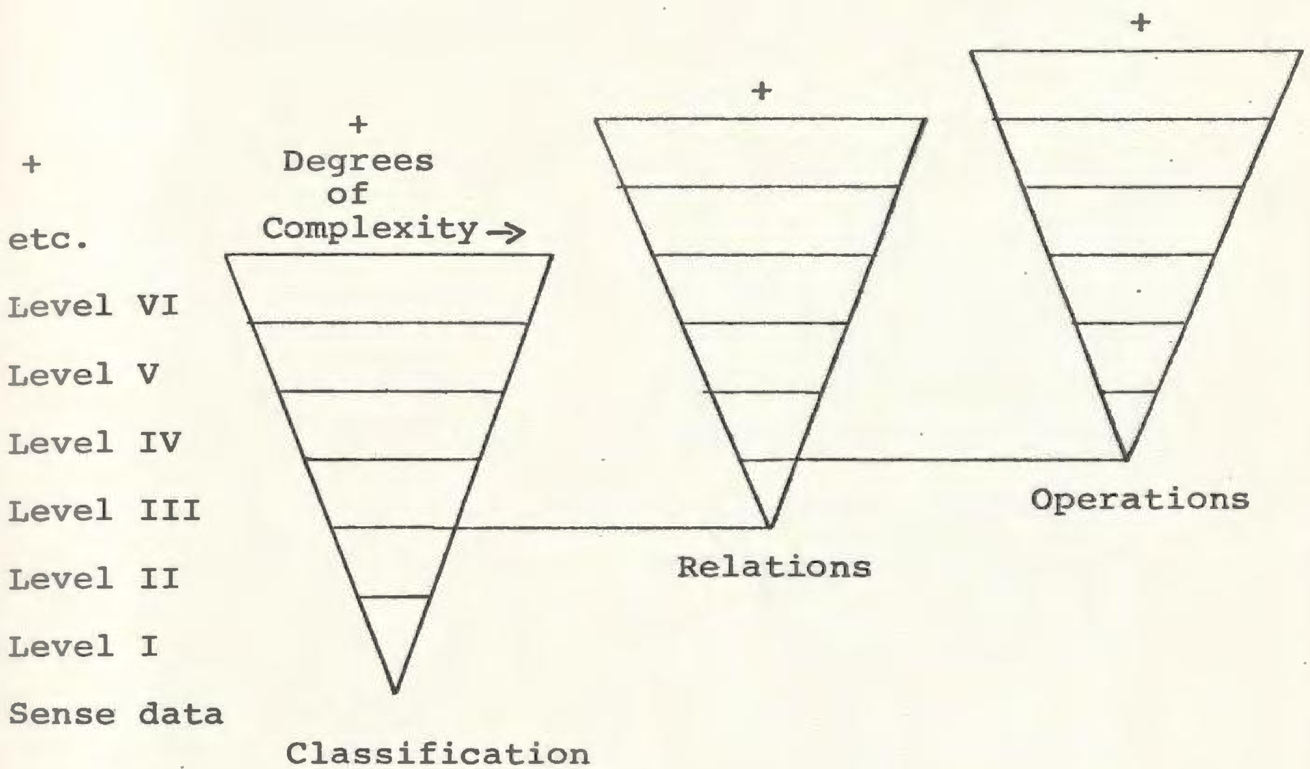
Figure 1 outlines the three orders of abstraction as defined by Lowell.

The three orders of representing experience form an hierarchy with classification at the bottom, followed by relations, with operations at the top. At the lowest levels of classification are concrete, sense data experiences progressing to entirely symbolic generalizations at the highest level, operations. Lowell's rationale for constructing the three orders is dependent upon his definition of abstraction set forth earlier.

This study was specifically concerned with the Classification Order and the hierarchical test based on this order. A general overview of the Order of Classification will be presented here since a detailed description of it

FIGURE 1

Lowell's Model of Abstraction*



The three cone-shaped structures represent the Orders of Classification, Relations, and Operations, respectively. The horizontal lines designate the various levels of abstraction in each Order. The levels are hierarchically arranged in order of increasing abstraction. Six levels are designated for the Order of Classification; however, it is conceivable more exist beyond six. These six levels are: Level I, Attribute Identification; Level II, Attribute Recognition; Level III, Object Recognition; Level IV, Class Recognition; Level V, Class of Classes Recognition, one class; Level VI, Class of Classes Recognition, two classes.

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*Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects" (Doctoral dissertation, Columbia University, New York, 1974), p. 7.

has been reported elsewhere.[27]

The Order of Classification. The Order of Classification consists of six levels (see Figure 2).

Figure 2 illustrates the hierarchical arrangement of the levels of classification. The levels are organized as follows: level one, Attribute Identification; level two, Attribute Recognition; level three, Object Recognition; level four, Class Recognition; level five, Class of Classes Recognition (one class); level six, Class of Classes Recognition. A detailed discussion of each level follows:

1. Level One--Attribute Identification: An attribute is a distinctive feature of a concept, and thus may vary from concept to concept. For example, the laboratory concept of red circles has two attributes, color and form (or shape). In the simplest form of learning, a subject may abstract a specific attribute or attributes of an object without verbally labelling this attribute. For example, it is possible for a subject to recognize that an object is a circle without being able to attach the word circle to that attribute. Such a process as the one described is known as Attribute Identification.

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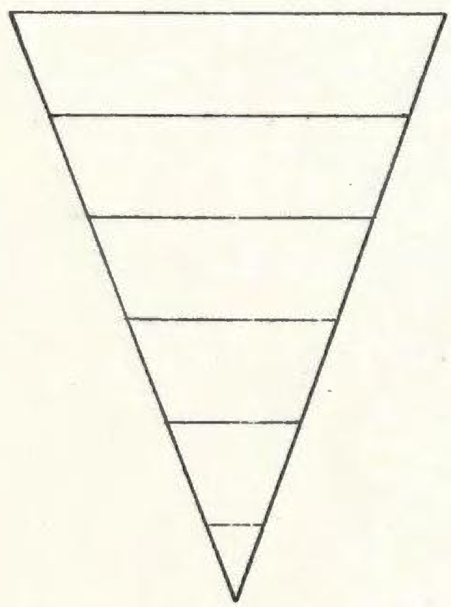
[27]Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects," (Doctoral Dissertation, Columbia University, New York, 1974), pp. 20-27.

FIGURE 2

Order of Classification*

Disjunctive Conjunctive

Degrees of Complexity →



Level VI	Class of Recognition Two Classes)
Level V	Class of Classes Recognition (One Class)
Level IV	Class Recognition
Level III	Object Recognition
Level II	Attribute Recognition
Level I	Attribute Identification

Sense Data

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*Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects" (Doctoral dissertation, Columbia University, New York, 1974), p. 21.

2. Level Two--Attribute Recognition: This is when an individual is not only aware of discriminable attributes of an object but is capable of verbally recognizing a discrete attribute or attributes. In this instance, the subject is able to correctly assign a verbal label to an attribute or attributes. An example is when a subject is able to verbalize the attributes of an object such as an apple.

3. Level Three--Object Recognition: This is when an individual groups several specific attributes together and constructs an object name to stand for these attributes. An example of Object Recognition would be when an individual recognizes that an object is an apple when it has a certain color, form, size, or texture.

4. Level Four--Class Recognition: A class is a set of objects with one or more common attributes. The placing of such objects as bananas, oranges, and apples in the category of being fruit is an example of Class Recognition.

5. Level Five--Class of Classes Recognition (one class): This level consists of classes with similar attributes which can be grouped together to form a class of classes. Level five might involve, for example, the recognition of such things as fruit, meat, and vegetables as being food, or it might be to realize that cats, dogs, and whales are mammals.

6. Level Six--Class or Recognition (two classes): At this level there exists extremely broad generalized categories

which have powerful subsumptivity. An example of this level would be a category such as animal which would subsume all mammals such as cats, dogs, whales, plus non-mammalian living things.

Results from Studies Using Model

Two studies have been conducted on the model of abstraction proposed by Lowell. The first study was a comparative study of the abstract learning ability of mentally retarded and normal ability subjects. The study consisted of five groups, one group of mentally retarded subjects, with the remaining four groups consisting of students from public and private schools who were the chronological and mental age equivalents to the mentally retarded group.

In this study Lowell found that mental ability affected the performance of subjects on the classification hierarchy. The performance of the normal ability subjects was superior to that of the mentally retarded subjects. He also found that the performance of students enrolled in private schools was superior to that of public school students. However, an examination of the reasons for the superior performance of the private school students was not attempted in Lowell's study.

Lowell claims support for the validity of the classification hierarchy on the grounds that (1) the mentally retarded group achieved low levels and successively failed the upper levels, and (2) the other groups all exhibited difficulty in achieving criterion at the upper levels. That is, the average number of trials to criterion increased as the level of difficulty increased on the hierarchical scale.[28]

The second study conducted by Lowell on the model of abstraction was concerned with two issues: (1) to explore the relationship between subject performance on the hierarchical classification test and their developmental level as assessed by Piagetian tasks, and (2) to gain further information concerning the validity of the hierarchical model of abstraction.

The study consisted of one group of junior high students and one group of senior high students. The results of the study indicated that subjects categorized as Formal Operational achieved the highest level on the classification hierarchy. Students categorized as Transitional also experienced little difficulty. However, students categorized as Concrete did experience some difficulty. This finding held true for both Concrete groups, with the performance of the senior high students being superior to that of the junior high students.

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[28]Walter Edward Lowell, "An Empirical Study of a Model of Abstract Learning," Science Education, LXI, No. 2 (1977), 229-242.

The results of the second study provide further evidence that the model of abstraction and the test based on the model can be considered a valid indicator of cognitive ability. Support for the model is found in the fact that the hierarchical test is (1) able to distinguish between various developmental levels as ascertained by Piagetian tasks, and (2) that the average cumulative trials to criterion increased as the level of difficulty increased on the hierarchy scale.[29]

These two studies indicated that the model of abstraction proposed by Lowell offers a valid approach for the investigation of abstraction. However, these studies as such were only preliminary studies of the model and did not attempt a detailed investigation of factors influencing performance on the abstraction measure. This, along with the fact that the model has undergone limited exploration, suggests that further research needs to be conducted to further evaluate the model of abstraction. This study will, therefore, examine the influence of a number of learner variables on abstract learning ability. A review of the literature on the influence of these learner variables on abstraction follows.

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[29]Walter Edward Lowell, "A Study of Hierarchical Classification in Concrete and Formal Thought," (paper presented at the annual general meeting of the National Science Teachers Association, Toronto, March 1978).

Psychological Variables Influencing Abstract Cognition: A General Survey

Age is a factor that is most commonly considered in studies dealing with abstraction. Hunt notes that cognitive development can be characterized by a series of stages involving abstract ability. Thus, as a child develops, he adds to the cognitive tools he has available to solve a concept-learning problem. On discussing high-order abstractions, Hunt further notes that the ability to respond to such abstractions, instead of all characteristics of a concrete object, is common in adults.[30]

Studies carried out by Welch and Long suggest that not only does the ability to conceptualize increase with age but also the level of conceptualization increases with age.[31] Vinacke, in reviewing the work of Welch and Long, as well as others, also found evidence to suggest that chronological age is at least as important as mental age.[32]

Travers draws the conclusion from concept learning research that concept learning skills increase with age

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[30] Earl B. Hunt, Concept Learning (New York: John Wiley and Sons, Inc., 1966), p. 167.

[31] Livingston Welch, "A Behaviorist Explanation of Concept Formation," The Journal of Genetic Psychology, LXXI, No. (1947), 211-215.

[32] Edgar W. Vinacke, "The Investigation of Concept Formation," Psychological Association, XLVIII, No. (1951), 11-17.

(children).[33] Ausubel similarly cites numerous studies in support of the argument that a child's ability to abstract increases with age.[34] Katz, and Pishkin in their studies of concept formation also found age to be a significant variable.[35,36]

In a study undertaken by Osler and Trautman it was found that in consideration of the independent variables age, intelligence, and mode of concept representation, that only age produced significant differences in concept attainment.[37]

D.C. Clark reports that as age increases so does the ease of concept attainment. Clark found this to be true in sixteen out of nineteen studies that he reviewed on the topic.[38]

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[33]Robert M. Travers, Essentials of Learning (New York: The MacMillan Company, 1967), pp. 264-269.

[34]David P. Ausubel, Educational Psychology: A Cognitive View (New York: Holt, Rinehart and Winston, Inc., 1968), p. 193.

[35]Phyllis A. Katz, "Role of Irrelevant Cues in the Formation of Concepts by Lower-Class Children," Journal of Educational Psychology LIX, No. 4 (1968), 233-238.

[36]Vladimir Pishkin, Aaron Wolfgang, and Elizabeth Rasmussen, "Age, Sex, Amount and Type of Memory Information in Concept Learning," Journal of Experimental Psychology, LXXIII, No. 1 (1967), 121-124.

[37]Sonia F. Osler, and Grace E. Trautman, "Concept Attainment II: Effect of Stimulus Complexity upon Concrete Attainment at Two Levels of Intelligence," Journal of Experimental Psychology, LXII, No. 1 (1961), 9-13.

[38]D.C. Clark, "Teaching Concepts in the Classroom," Journal of Educational Psychology, LXII, No. 3 (1971), 258-259.

Although most of the research in this area suggests that the ability to conceptualize increases with age there is some question as to what extent age actually contributes. Gagné feels that concept formation is not simply ascribable to the process of growth.[39] Inhelder and Piaget elaborate further on this point when they question the extent to which maturation influences the formation of classification. They add that maturation itself is subject to laws of equilibrium insofar as there is bound to be an interaction between maturation and experience, both social and material.[40]

There is a limited amount of research which suggests that age is not a significant factor in concept development. Clark reported this to be true for only three out of nineteen studies he reviewed on the topic.[41] Klugh, and Friedman, however, found an inverse relationship between developmental level and concept learning.[42,43]

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[39]Robert M. Gagné, The Conditions of Learning (New York: Holt, Rinehart and Winston, Inc., 1970), pp. 289-291.

[40]Barbel Inhelder and Jean Piaget, The Early Growth of Logic in the Child (New York: W.W. Norton and Company, Inc., 1969), p. 293.

[41]Clark, pp. 258-259.

[42]H.E. Klugh, and Karen Roe, "Developmental Level and Concept Learning: Interaction of Age and Complexity," Psychonomic Science, II, No. (1965), 385-386.

[43]Stanley R. Friedman, "Developmental Level and Concept Learning: Confirmation of an Inverse Relationship," Psychonomic Science, II, No. (1965),

In researching the area of concepts, sex is a variable that is not often explored. Nevertheless, one of the most thorough reviews of research on this variable has been conducted by Clark. Clark reports that in ten out of fourteen studies which measured the influence of sex on the ease of concept attainment, the sex of the student did not appear to be a significant variable in the ease with which the concepts were attained.[44]

There is strong evidence from research to support the hypothesis that the higher the IQ the higher the abstract learning ability. Clark reports that in eight out of twelve studies conducted on the ease of concept attainment it was found that as intelligence increases so the ease of concept attainment generally increases.[45]

Furth studied observable nonverbal conceptual behavior in relation to age, intelligence and language for hearing and deaf children, aged 6-10 and 14. He found that conceptualization could be postulated as being related to IQ but only minimally associated with age or language.[46]

Katz found that proficiency in concept formation is related to developmental level in children, as assessed by both chronological age and IQ. She notes that this finding is in accordance with a number of other studies

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[44]Clark, p. 259.

[45]Clark, p. 259.

[46]Hans G. Furth, "Conceptual Discovery and Control on a Pictorial Part-Whole Task as a Function of Age, Intelligence, and Language," Journal of Educational Psychology, LIV, No. 4 (1973),

(e.g. Inhelder and Piaget, 1958; Long and Welch, 1941; Osler and Fivel, 1961; Sigel, 1953).[47]

Vinacke in reviewing work in the area of concept formation reports that it is probably safe to say that psychologists have assumed that intelligence and concept formation are related, although they have not yet worked out the relationship explicitly. He further elaborates that this is based on the assumption that one of the variables of intelligence is the ability to form and use concepts and that part, at least, of the reason that mental age increases during the period of growth is that the ability to conceptualize increases.[48]

Bayley concludes that it would appear that motivation, drive, and ample time, rather than small variations in intelligence are the important determiners for much of learning in adults.[49]

Osler and Trautman report in their study (of the effect of stimulus complexity on concept attainment) that the effect of intelligence was insignificant except in the

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[47]Katz, pp. 233-238.

[48]Vinacke, p. 18.

[49]Nancy Bayley, "Learning in Adulthood: The Role of Intelligence," Analyses of Concept Learning, eds. Herbert J. Klausmeier, and Chester W. Harris (New York: Academic Press, 1966), pp. 117-137.

interaction of intelligence and method of presentation.[50]

Another variable which is worthy of consideration is the effect of schooling on abstraction. Studies by such people as Irving Lorge and R.L. Thorndike show that the amount of schooling received is definitely related to intelligence test performance.[51,52] Since abstraction or the ability to abstract is at least one dimension or intelligence then it can be concluded that schooling should also influence the ability to abstract.

Piaget's work in the area of cognition, especially as it pertains to children and adolescents, suggests that the progression through stages of cognitive development is influenced by social transmission--language and education (i.e. schooling).[53]

Vinacke similarly notes that in studies conducted by such people of Deutsche, Oakes, and Ordan, children differ in their concepts and use of concepts as much because of variations in experience as because of variations in intelligence.[54]

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[50]Sonia F. Osler, and Grace E. Trautman, "Concept Attainment II: Effect of Stimulus Complexity Upon Concept Attainment at Two Levels of Intelligence," Journal of Psychology, LXII, No. 1 (1961), 9-13.

[51]I. Lorge, "Schooling Makes a Difference," Teachers College Record, XLVI, No. 4 (1945), 483-492.

[52]R.L. Thorndike, "Growth of Intelligence During Adolescence," Journal of Genetic Psychology, LXXI, No. (1948), 11-15.

[53]Inhelder, and Piaget, p. 293.

[54]Vinacke, pp. 18-19.

Lowell found in his study of abstract learning ability a significant difference in the ability of students enrolled in private and public schools. The students enrolled in the private schools performed significantly better than those enrolled in public schools. Lowell accounts for this by the fact that private schools probably offer a better quality of education and that students enrolled in such schools are likely to have had a privileged background.[55]

In a second study undertaken by the same researcher it was found that performance of subjects with 9-11 years of schooling was superior to that of subjects with 7-8 years of schooling.[56] This seems to suggest that schooling could possibly account for such a difference although such variables as age also need to be taken into consideration.

Stein and Susser offer a similar argument to that presented by Lowell in his first study. They argue that the level of the intelligence quotient is not determined solely by social and economic conditions, but there is a mounting body of data showing that it is also related to

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[55]Walter Edward Lowell, "An Empirical Study of a Model of Abstract Learning," Science Education, LXI, No. 2 (1977), 235-236.

[56]Walter Edward Lowell, "A Study of Hierarchical Classification in Concrete and Formal Thought," (paper presented at the annual general meeting of the National Science Teachers Association, Toronto, March 1978).

the quality of schooling.[57]

Kendler, another researcher working in this area reports that the ability to notice and manipulate abstractly defined symbols decreases from college through kindergarten and nursery school. She speculates that this is probably because of neurological development rather than educational practice.[58]

Summary

The review of literature has revealed that although abstraction is the subject of numerous investigations it is still not well understood. In an attempt to offer a valid framework for research, the present investigator has assumed that all the various processes that are often ascribed to abstraction can be subsumed under a definition of abstraction. A definition based on this assumption forms the basis of a model of abstraction that is to be explored in this study.

In addition, the review of literature has revealed that abstract ability is a function of a number of variables, including age, sex, IQ, and schooling. Although the reviewed

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[57] Z. Stein, and M. Susser, "Mutability of Intelligence and Epidemology of Mild Mental Retardation," Review of Educational Research, XL, No. 1 (1970), 29-85.

[58] Tracy S. Kendler, "Learning Development and Thinking," Fundamentals of Psychology: The Psychology of Thinking, ed. E. Harms (New York: New York Academy of Science, 1960), pp. 52-56.

studies indicate that age, IQ, and schooling are significant while sex is not significant, these studies are not conclusive in terms of the contribution of age, sex, IQ, and schooling to abstraction. This suggests a closer examination of the influence of these variables in the process of abstraction.

CHAPTER III

METHODS AND MATERIALS

Population and Sample

Introduction

This study was based on a sample of 195 subjects divided into six groups. The six groups consisted of three groups of adults and three groups of public school students. The sample parameters of these six groups are displayed in Table 1.

The three adult groups, functioning at three different grade levels, were randomly chosen from three adult education centers. The functional grade levels of the three adult groups determined the remaining three non-adult or public school groups.

Adult subjects. Group 1 was selected from the population of adults enrolled in the Basic Literacy Program at the Adult Education Center in Stephenville. The Basic Literacy Program is designed for adults whose skills in the particular subjects of English and Mathematics are below grade five level as measured on standardized tests. Group 1 consisted of 42 subjects with a mean functional grade level of 4. Due to the nature of the program at the

TABLE I

Population Parameters

		ADULT			NON-ADULT		
		Group 1 Stephenville	Group 2 College of Fisheries	Group 3 College of Trades	Group 4 Elementary	Group 5 Junior High	Group 6 Senior High
AGE	Range	197-509* 16-5 - 51-1**	211-552* 17-7 - 46-0**	229-353* 19-1 - 29-5**	112-124* 9-4 - 10-4**	171-187* 14-3 - 15-7**	195-210* 16-3 - 17-6**
	Mean	306.02* 25-6**	275.56* 22-11**	249.47* 20-8**	117.63* 9-9**	177.33* 14-9**	200.50* 16-8**
	SD	116.63* 9-7**	67.23* 5-6**	29.48* 2-5**	3.60* 0.30**	4.14* 0.345**	3.71* 0.309**
IQ	Range	49-101[a]	77-139[b]	92-116	92-141	89-126	94-125
	Mean	81.69	107.23	103.33	116.67	106.67	106.90
	SD	12.98	18.09	6.55	10.71	11.08	7.81
SEX	Female	13	13	14	15	15	14
	Male	29	20	16	15	15	16
Functional Grade Level		4	9	>11	4	9	>11
N		42	33	30	30	30	30

[a] IQ scores available for 39 subjects
[b] IQ scores available for 26 subjects

*Age in months
**Age in years

institution, it was impossible to choose a group of adult students at a specific functional grade level. That is, students enrolled in such programs were allowed to progress at their own rate.

Group 2 was selected from the population of adults in The Basic Training in Skills Development (BTSD) program at the College of Fisheries, St. John's. This program is designed to develop skills in English, Mathematics, and Science beyond the grade five level. Group 2 consisted of 33 subjects with a mean functional grade level of 9. Again, for the same reason as cited above, it was impossible to select a group of adult students at a functional grade level of 9.

Group 3 was randomly selected from the population of adult students enrolled in post-secondary studies at the College of Trades and Technology, St. John's. This group consisted of 30 subjects, functioning at or above the grade 11 level.

Non-adult subjects. The subjects in the three non-adult groups were selected as being the functional grade equivalents to the adult groups. The criteria for selecting the non-adult equivalents required that the subjects be reading at grade level and that the subjects be of average or better academic ability (achieving an average of at least 60% at mid-year).

In selecting the non-adult subjects three schools (one elementary, one junior high school, and one senior high school) were randomly selected from the schools in St. John's. Within the chosen school subjects were then randomly selected from the appropriate grade level. Groups 4, 5, and 6 consisted of 30 subjects each, with functional grade levels of 4, 9, and at or above 11.

Instrumentation

Test of Natural Phenomena

Description. The instrument used in this study is known as The Test of Natural Phenomena. It was developed by W.E. Lowell as part of his doctoral thesis at Columbia University, New York. The Test of Natural Phenomena is designed to test the limits of abstract learning in a classification scheme hierarchically organized from concrete attribute identification to abstract class recognition. The hierarchical arrangement of the test is based on the theoretical model discussed earlier.

Testing procedure. All tests used in the study were individually administered to all subjects. The administration of the test consisted of presenting a series of tasks representing each level of abstraction in The

Test of Natural Phenomena. Each task consisted of two boxes. The contents of the first box presented to the subjects contained two examples of the instances to be taught. Once the examples had been presented, the box and its contents were removed and the second box was presented. The second box contained two examples of the instances taught plus four distractors. The subjects were asked to select examples of the instances taught them.* Since the contents of the second box were used to assess the subjects' ability to acquire the abstraction taught him, no verbal cues were given. All tests for the six levels of abstraction in The Order of Classification were constructed and presented in this manner.

The criterion level for achievement was successful completion of the task within two trials. Upon successful completion of Level I, the subject was taught Level II, in the same manner and with the same criteria for success. Successful completion of the test occurred when the subject identified both instances correctly. Unsuccessful completion of the test occurred when the subject (a) failed to identify either instance correctly, (b) only identified one instance correctly, or (c) identified both instances correctly but placed one or more incorrect instances in the correct group.

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*The probability of a chance combination of correct instances on each trial is 1/6 x 1/6 = 1/36.

The presentation sequence and the success criterion continued until the Level VI test terminated the testing sequence.

If a subject failed to achieve a particular level within two trials, the testing sequence was still continued to the highest level. By testing to the highest level, it was possible to detect whether subjects can, by some cognitive process that was not predicted in the rationale of this study, go to a higher level after failing a lower one. It was anticipated that, if the hierarchy is properly organized, most subjects will not be able to achieve a higher level after failing a lower one.

Scoring procedure. The Test of Natural Phenomena consists of six levels which are made up of eight tests.

LEVEL	TEST
I	1
II	2
III	3
IV	4,5
V	6,7
VI	8

On the basis of performance on the test subjects were given scores for level (1 point for each level to a maximum of 6) and test (1 point for each test to a maximum of 8). The rule for determining the highest level or test was to give credit to the highest test or level passed provided that the subject had successfully passed all subordinate tests. However, if subjects passed higher level tests but failed one or more subordinate tests they were still given credit for their maximum test and level they achieved but their performance on The Test of Natural Phenomena was considered as anomalous behavior.

Reliability and Validity. The validity and reliability of The Test of Natural Phenomena was initially established in the first study conducted by Lowell.[59] In that study Lowell examined the hierarchical classification ability of five different groups.

In attempt to establish reliability of the instrument Lowell tested 10 subjects from one of the five groups five weeks after the initial testing. With respect to the reliability for these 10 subjects, six subjects achieved the exact same level, two subjects dropped from Level III to Level II and two subjects achieved higher levels, one going from V to VI, and the other from Level I to II. Lowell considered the test reliable since all but two subjects scored at or below their original performance.

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[59]Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects," (Doctoral Dissertation, Columbia University, New York, 1974), pp. 50-51.

His criteria for the establishment of the validity of the instrument is based on the assumption that the hierarchical organization of abstraction was correct. That is, subjects who failed to achieve the lower level of the test should also fail successive higher levels. Lowell found that 82.6% of subjects among all groups tested meet this criterion. He attempted to account for the anomalous behavior of 17.4% of subjects who did not meet criterion by noting that the perceptual set of subjects was influenced by instructional presentation. These findings supported The Order of Classification as an indicator of human abstract ability.

One aspect of this study was to further evaluate the reliability and validity of The Test of Natural Phenomena. While this study was not directly concerned with testing the reliability and validity of the abstraction measure, such concerns are of obvious importance since unreliable or invalid measures would necessarily invalidate the study and model. Since these issues are of importance and as an estimate of them, the results of the abstraction measure will be compared with the results (or abstraction measure) of comparable groups in previous studies. Widely varying or contradictory results across comparable groups would then be considered as an indicator of a unreliable or invalid measure. In addition, to further establish instrument reliability and validity it will be necessary to examine the average cumulative trials to criterion taken by each group for all eight tests. Such an analysis will provide evidence as to the amount of difficulty experienced by each group at each test level. Since The Test of Natural Phenomena is supposedly an hierarchical test the amount of difficulty experienced should increase as the tests progress up the hierarchical scale. Also, groups of different educational backgrounds should experience varying amounts of difficulty at each level of the hierarchical scale.

Other Instruments: The Quick Test (QT)

Description. The Quick Test (QT) is a screening instrument for measuring verbal-perceptual intelligence. QT is an individualized IQ test developed by R.B. Ammons and C.H. Ammons. It provides norms for both adult and non-adult populations. The QT is published in three single forms comprised of 50 word items.

Testing Procedure. All three forms of the QT were individually administered to Groups 3, 4, 5, and 6. Due to the limited accessibility of subjects in Groups 1 and 2 for IQ testing, IQ data that was collected by their educational institutions was used. This data was based on Wechsler IQ norms as was the QT. The QT was administered to the subjects described above at the same time as The Test of Natural Phenomena. However, in an attempt to eliminate the effect of testing both of these tests were administered alternately.

Reliability and Validity. Ammons and Ammons established the validity of the QT by comparing it with the Full-Range Picture Vocabulary Test. They also reported correlations between the FRPV and several other measures. These correlations are .73 with the Stanford-Binet; .86 with the Wechsler-Bellevue Vocabulary; and .85 with the Wechsler Adult Intelligence Scale. Using these correlations as a validity criterion, they report correlations between the QT and the Full-Range Picture Vocabulary Test (FRPV) (Forms A and B combined) as follows: Form 1, .79; Form 2, .80; Form 3, .64; and Forms 1 + 2 + 3, .82. The two tests cover similar mental age ranges. The mental age lower limit for the QT is 1.5 years compared to 1.75 years for the Peabody Picture Vocabulary Test (PPVT). The tests have the same upper limit of 18.0 years, after which adult IQ norms are used.[60]

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[60]T.E. Standburg, J. Griffith, and L. Winer, "Child Language and Screening Intelligence," Journal of Communication Disorders II, No. 3 (1969), 268-272.

Methods of Analysis

Path Analysis

Group performance on The Test of Natural Phenomena will be analyzed by a generalization from multiple linear regression to systems of causal relations known as path analysis. Multiple linear regression has been recognized as having great potential for investigating the relationship between a set of independent variables and a dependent variable. The basic assumption underlying the use of multiple linear regression is that there exists a linear relationship between the set of independent variables and the dependent variable. Information about the independent variables then gives the investigator certain predictive ability about the dependent variable.

The multiple correlation coefficient (R) is a measure of the goodness of fit between the observed and predicted values for the dependent variable. Its square, the squared multiple correlation (R^2) represents the amount of variance of the dependent variable accounted for by the full linear equation, usually called model 1. To investigate the effect of a particular variable such as age, a second equation, usually called model 2, is used omitting that particular variable. It is possible to test the significance of the contribution of any one variable in the presence of others by computing an F ratio, which incorporates the difference between the R^2 of the full model and that of the restricted model.

In an attempt to further define the relationship between the independent and the dependent variables path analysis, a procedure introduced by Sewell Wright, is used as a method of decomposing and interpreting linear relationships among the set of variables.

Assumptions. Among the assumptions that underlie the application of path analysis are:

1. The relations among the variables in the model are linear, additive, and causal. Consequently, curvilinear, multiplicate, or interaction relations are excluded.

2. The residuals are not correlated among themselves, nor are they correlated with the variables in the system. The implication of this assumption is that all relevant variables are included in the system. Endogeneous variables are conceived as linear combinations of exogenous or other endogeneous variables in the system and a residual. Exogenous variables are correlated among themselves, these correlations are treated as "givens" and remain unanalyzed.

3. There is a one-way flow in the system. That is, reciprocal causation between variables is ruled out.

4. The variables are measured on an interval scale.[61]

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[61]Fred N. Kerlinger, and Elazer J. Pedhazur, Multiple Regression in Behavioral Research (New York: Holt, Rinehart and Winston, Inc., 1973), p. 309.

An exception to the last assumption (No. 4 above), having to do with the type of measurement used, should be made at this time. The data used in this study is based on a test score derived from performance on the classification hierarchy. Some would argue that such a score is ordinal because it is derived from performance on an hierarchical scale which suggests unequal, non-additive intervals. However, the present investigator would disagree with such an argument on the grounds that the scoring system used for the dependent variable, classification, is based on a 9-point scale (0-8), and it is at its worst only a mildly distorted version of an interval scale.

A clear decision on data type is critical to this study in that the method of data analysis used assumed the use of an interval scale. However, there is some support for the use of path analysis in situations where the type of variable measurement is not clearly defined. Gardner has discussed the pros and cons that statisticians have presented on such issues. The following is an outline of his conclusions:

1. The distinction between ordinal and interval scales is not sharp. Many summated scales yield scores that, although not strictly of interval strength, are only mildly distorted versions of an interval scale.

2. Some of the arguments underlying the assertion that parametric procedures require interval strength

statistics appear to be of doubtful validity.

3. Parametric procedures are, in any case, robust and yield valid conclusions even when mildly distorted data are fed into them. Furthermore, if the distortions are severe, various transformation techniques can be applied to the data.

4. For some kinds of research design, parametric procedures retain a number of important experimental benefits: they possess (1) greater sensitivity, (2) the ability to detect interaction effects in factorial experiments, and (3) the ability to yield estimates of the magnitudes of treatment effects.[62]

Labovitz further asserts that ordinal type variables can be treated as if they conform to interval scales. Some of the advantages Labovitz gives for the treating of ordinal variables as though they conformed to interval scales are:

1. The use of more powerful, sensitive, better developed and interpretable statistics with known sampling errors;

2. The retention of more knowledge about the characteristics of the data; and

3. Greater versatility in statistical manipulation, for example, partial and multiple regression.[63]

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[62] P.L. Gardner, "Scales and Statistics," Review of Educational Research, XLV, No. 1 (1975), 43-57.

[63] S. Labovitz, "The Assignment of Numbers to Rank-Order Categories," American Sociological Review, XXXV, No. 3 (1970), 515.

These arguments have been taken as sufficient justification to treat the measurement of the classification variable in the model presented in this study as if it conformed to an interval scale.

Path Model. In this study a five-variable, general path analysis model was proposed for path analysis. The path analysis model is

> a method of measuring the direct influence along each separate path in . . . a system and thus of finding the degree to which variation of a given effect is determined by each particular cause. The method depends on the combination of knowledge of the degree of correlation among the variables in a system with such knowledge as may be possessed of the causal relations.[64]

The path model used in this study is presented in Figure 3. It is drawn according to conventional procedure.[65] The system as presented in Figure 3 is called a "recursive" system, as contrasted with a system in which there may be a reciprocal causation, and can be represented by a structural equation where

X_5 = group (as defined by functional grade level)

X_4 = age

X_3 = IQ

X_2 = sex

X_1 = classification ability

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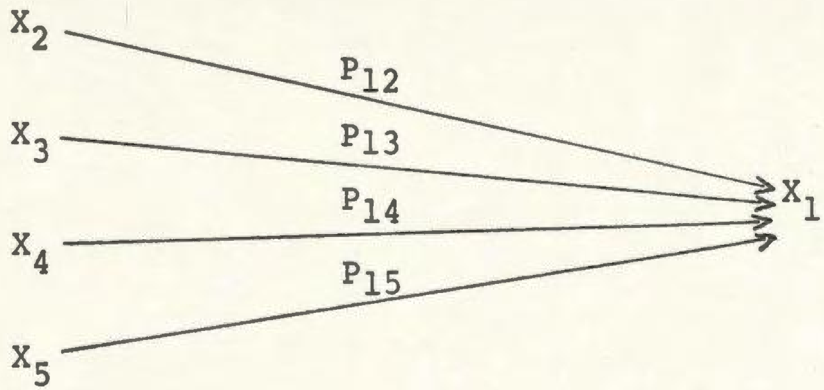
[64] S. Wright, "Correlation and Causation," Journal of Agricultural Research, XX, No. 6 (1921), 557-585.

[65] Kerlinger, and Pedhazur, pp. 307-309.



$X_5 \geqslant X_4 \geqslant X_3 \geqslant X_2 \geqslant X_1$*

X_1 - classification abilities

X_2 - sex

X_3 - IQ

X_4 - age

X_5 - group

P_{ij} - path coefficient

*$\geqslant$ symbol designates a weak casual order. The symbol should not be taken to mean "equal to or greater than."

FIGURE 3. Schematic Diagram for a General Path Analysis of a Five-Variable Path Analysis Model.

P = the path coefficient representing magnitude of the cause-effect relationship. The subscripts specify the two variables in question, for example, P_{15} represents the magnitude of X_5 as a cause of X_1.

When nominal-scale variables appeared in the regression analysis dummy variables will be used to insert the nominal-scale variable into the regression equation. Since the numbers assigned to categories of a nominal scale are not assumed to have an order and a unit of measurement, they cannot be treated as "scores" as they would in a conventional regression analysis.

A set of dummy variables was created by treating each category of a nominal variable as a separate variable and assigning arbitrary scores to all cases depending upon their presence or absence in each of the categories. Since dummy variables have arbitrary values of 0 and 1, they may be treated as interval variables and inserted into a regression equation. However, the inclusion of all dummies created from a given nominal variable would render the nominal equation unsoluable because the κth dummy variable is determined by the κ-1 dummies entered into the regression equation. It is therefore necessary to exclude one of the dummies from the equation. In this case, the independent variable group was entered as a dummy variable, with group 6 being excluded in the path analysis of non-adult subject, and all subjects whereas group 3 was excluded in the path analysis of non-adult subjects.

CHAPTER IV

ANALYSIS OF DATA

Part I: Analysis of Variables Affecting Classification

Introduction

This chapter presents the results of the analyses carried out in the process of quantification and further elaboration of the causal model presented earlier in this study. In the analysis of the effects of the independent variables (age, sex, IQ, and functional grade level) on the dependent variable abstract learning ability (as measured by the hierarchical classification test) the results of basic statistical analyses of average level achieved, average cumulative trials to criterion, and correlation coefficients will be presented first, followed by path coefficients and the coefficients of determination for each of the independent variables.

Average Level Achieved

Table II displays the mean and standard deviation of the test score and the level achieved by each of the six groups on The Test of Natural Phenomena. The maximum level that a subject could achieve was 6, the highest level

TABLE II

Average Level Achieved Per Group

Group	Average Level[a] Achieved	SD	Average Test Score Achieved	SD	N
1	3.12	1.04	3.88	1.52	42
2	3.73	1.04	4.88	1.73	33
3	5.50	0.86	7.43	1.07	30
4	3.77	1.31	4.83	1.97	30
5	4.73	1.14	6.40	1.60	30
6	5.33	0.76	7.23	1.01	30

Group 1 = Adults of Functional Grade Level < 5

Group 2 = Adults of Functional Grade Level $5 < x \leq 11$

Group 3 = Adults of Functional Grade Level ≥ 11

Group 4 = Non-adults of Functional Grade Level < 5

Group 5 = Non-adults of Functional Grade Level $5 < x \leq 11$

Group 6 = Non-adults of Functional Grade Level ≥ 11

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[a]The scores for the highest level achieved for each subject for each group are found in Appendix C. Eight tests constitute six levels of abstraction in the following sequence: Subtest 1 (Level 1); Subtest 2 (Level 2); Subtest 3 (Level 3); Subtest 4 and Subtest 5 (Level 4); Subtest 6 and Subtest 7 (Level 5); Subtest 8 (Level 6).

in the classification hierarchy. To reach level 6, the subject had to pass eight subtests which comprise the Order of Classification.

Table II shows that as the functional grade level of both the adult and non-adult groups increases so does the performance on The Test of Natural Phenomena increase. Table II also shows that the performance of non-adult subjects of functional grade levels 4 and 9 was superior to the adults of equivalent functional grade levels. However, the performance of adults of functional grade level 11 was superior to non-adults of the same functional grade level.

Average Cumulative Trials to Criterion

The six level Test of Natural Phenomena is composed of eight subtests. The minimum number of cumulative trials to reach level 6 is eight (when criterion is achieved in one trial for each of the eight subtests) and the maximum number is 16 (two trials required to reach criterion on each subtest). Since all eight tests were administered to each subject, the average cumulative number of trials taken by each group for all eight tests provides evidence as to the amount of difficulty each group experienced with The Test of Natural Phenomena. The average cumulative trials for all eight tests were tabulated and are set forth in Table III. Table III shows that as the functional grade level

TABLE III

Average Cumulative Trials to Criterion Per Group

Level	Test	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
I	1	1.14	1.06	1.03	1.06	1.07	1.13
II	2	2.33	2.09	2.03	2.16	2.14	2.20
III	3	3.42	3.18	3.03	3.33	3.31	3.20
IV	4	4.82	4.39	4.16	4.73	4.41	4.23
	5	6.80	6.36	5.83	6.66	6.31	5.80
V	6	8.54	8.00	7.16	8.53	7.84	7.20
	7	10.35	9.52	8.39	10.03	9.11	8.37
VI	8	12.31	11.49	10.02	11.86	10.89	9.97
		N=42	N=33	N=30	N=30	N=30	N=30

Group 1 = Adults of Functional Grade Level < 5

Group 2 = Adults of Functional Grade Level $5 < x \leq 11$

Group 3 = Adults of Functional Grade Level ≥ 11

Group 4 = Non-adults of Functional Grade Level < 5

Group 5 = Non-adults of Functional Grade Level $5 < x \leq 11$

Group 6 = Non-adults of Functional Grade Level ≥ 11

of both the adult and non-adult groups increases there is a decrease in the cumulative trials needed to complete The Test of Natural Phenomena.

Correlation Coefficients

Tables IV and V present the product-moment correlations plus means and standard deviations on which all the remaining calculations presented here are based. Table IV considers the overall relationship for all subjects in the study whereas Table V looks at the relationship for adult and non-adult subjects. Each correlation was computed on all cases for which data were available, and hence the correlations are based on different numbers of cases in some instances. An examination of the case base in Table IV will reveal that data on age and IQ was not available for a limited number of subjects in Groups 1 and 2.

Relationship Between Dependent and Independent Variables. The correlations that are discussed in this section are those significant correlations between hierarchical classification ability as measured on The Test of Natural Phenomena and (1) age, (2) sex, (3) IQ, (4) functional grade level. Matrices of all possible correlations for all subjects, adults, and non-adults are presented in Tables IV and V.

In the production of the correlation matrices the dependent variable, hierarchical classification ability was

TABLE IV

Correlation Matrix, Case Base, Means, and Standard Deviations

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	Mean	SD
X_1		-.18	-.18	-.19	-.22*	.14	.16	.11	-.23**	-.06	0.15	0.36
X_2	195		-.18	-.19	-.22*	.16	.17	.38***	-.53***	-.06	0.15	0.36
X_3	195	195		-.19	-.22	.38***	.38***	.02	.12	-.03	0.15	0.36
X_4	195	195	195		-.24**	.18	.17	.11	.22*	.03	0.17	0.38
X_5	195	195	195	195		.44	.46***	-.66***	.49***	.13	0.22	0.41
X_6	195	195	195	195	195		.98***	.34***	-.15	.06	4.28	1.37
X_7	195	195	195	195	195	195		.35***	-.18	.05	5.65	2.03
X_8	185	185	185	185	185	185	185		-.47***	.02	102.6	16.33
X_9	187	187	187	187	187	187	187	179		.03	225.08	89.27
X_{10}	195	195	195	195	195	195	195	185	187		1.57	0.50

Note: The values above the diagonal are the correlation coefficients, and the case base on which they are based are below the diagonal.

*significant at .05 level
**significant at .02 level
***significant at .01 level

Key: X_1 = Group 5; X_2 = Group 4; X_3 = Group 3; X_4 = Group 2; X_5 = Group 1; X_6 = Level; X_7 = Test; X_8 = IQ; X_9 = Age; X_{10} = Sex.

TABLE V

Matrix of Product Moment Correlations Separately by Age Groups

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1		-.50***	-	-	-	.07	.09	.22*	.25**	-.02
X_2	-		-	-	-	.48***	.51***	.43***	.95***	-.02
X_3	-	-		-	-	-	-	-	-	-
X_4	-	-	-.43***		-	-	-	-	-	-
X_5	-	-	-.52***	-.55***		-	-	-	-	-
X_6	-	-	.69***	-.13	.51***		.99***	-.03	.50***	.14
X_7	-	-	.68***	-.11	.53***	.98***		-.05	.53***	.13
X_8	-	-	.31***	.41***	.66***	.46***	.48***		-.43***	.09
X_9	-	-	.24**	-.04	.25**	-.19	-.23**	-.19		.02
X_{10}	-	-	-.11	-.02	.12	.04	.04	.06	-.04	

Notes: a. Correlations for non-adults above the diagonal; adults below
b. Table V provides the key to the variable names.

*significant at .05 level
**significant at .02 level
***significant at .01 level

assigned two names, test and level. Test and level are both measures of hierarchical classification ability, with test being the number of classification tests passed, and level being the level of classification ability achieved on the classification hierarchy. In reviewing the scoring procedure for the Test of Natural Phenomena it is noted that it consists of 8 tests which constitutes 6 levels. The test and level format of the Test of Natural Phenomena is briefly outlined below:

LEVEL	TEST
I	1
II	2
III	3
IV	4
	5
V	6
	7
VI	8

The rule for scoring was to award to all subjects 1 point for each test (to a maximum 8) and 1 point for each level (to a maximum 6). Based on this scoring system subjects were therefore awarded a score for the number of tests and levels that they successfully completed.

<u>Age and performance on Test of Natural Phenomena</u>. The correlation for non-adult (Groups 4-6) subjects between

age and level was .53, and between age and test was .50, which were both significant at the .01 level. The correlation for adult subjects (Groups 1-3) between age and test was -.23, significant at <.05 level.

<u>Sex and performance on Test of Natural Phenomena</u>. In the case of sex and hierarchical classification ability no significant relationship was found in any of the correlation analyses.

<u>IQ and performance on Test of Natural Phenomena</u>. When IQ and performance is considered no significant relationship was found for non-adult subjects. For adults the correlation between IQ and level was .46, and between IQ and test was .48, both of which were significant at the .01 level. With all subjects included in the analysis the correlation between IQ and level was .34, and between IQ and test was .35, with both significant at the .01 level.

<u>Functional grade level and performance on Test of Natural Phenomena</u>. For Group 4, non-adult subjects, the correlation between functional grade level and level was .48, with a correlation of .51 between functional grade level and test. These correlations were both significant at the .01 level. No significant correlations were found for the other non-adult groups. Groups 1 and 3 of the adult

subjects reported a correlation of .51, and .69 between functional grade level and level, and a correlation of .53, and .68 between functional grade level and test. All of these correlations were significant at the .01 level.

Relationship Between Independent Variables. The relationships between the independent variables, age, sex, IQ, and functional grade level for all subjects, adults and non-adults, are also presented in Tables IV and V. In an attempt to avoid a lengthy discussion of insignificant relationships among independent variables, a presentation of significant correlations among independent variables follows:

Age and IQ. The correlation for non-adults between age and IQ was -.43. This correlation was significant at the .01 level. In the case of adult subjects, however, no significant relationship was found between age and IQ.

Age and functional grade level. For non-adult subjects, Groups 4 and 5, the correlation between age and functional grade level was .95 and .25. These correlations were significant at the .01 and .02 level, respectively. The correlation for Groups 1 and 3 of the adult subjects was .25, and .24, both of which were significant at the .02 level.

IQ and functional grade level. For Groups 4 and 5 of the non-adult subjects correlation between IQ and functional grade level was .43, and .22. These correlations were significant at the .01, and the .05 levels, respectively. For Groups 1, 2, and 3 of the adult subjects correlations of .66, .41, and .31 were found with all correlations significant at the .01 level.

Multivariate Relationships

It must be recognized that when correlation coefficients are used to establish patterns of relationship between variables, the degree of association is in fact a rather crude measure. In educational research, it is generally accepted that the independent variables interact with one another, which in turn correlate with the dependent variables. Therefore, it is seldom the case that a direct one-to-one relationship exists between an independent variable and a dependent variable; rather the relationship is often influenced by extraneous variables. The single correlation coefficient number, then, can be misleading and in all likelihood denotes the relationship in question plus other things as well. It is for this reason that a second, but related, mode of analysis was conducted in an attempt to isolate the effect that each of the four predictor variables--age, sex, IQ, and functional grade level--had on the outcome variable, Performance on Test of Natural

Phenomena. This procedure requires the obtaining of an accurate estimate of the effect of one independent variable on the criterion while taking into account or controlling for the effect of the other independent variables.

Multiple regression, the second mode of analysis used in the present study, is a statistical technique through which one can more precisely analyze the relationships between a dependent or criterion variable and a set of independent or predictor variables. In this study, multiple regression was used as a descriptive tool by which the linear dependence of hierarchical classification ability on age, sex, IQ, and functional grade level was determined. This was done (1) by finding the best linear prediction equation and evaluating its prediction accuracy, and (2) by controlling for other possibly confounding factors in order to evaluate the relative contribution of age, sex, IQ, and functional grade level. That is, through multiple regression techniques the researcher was able to obtain a prediction equation that indicated how scores on the independent variables (age, sex, IQ, and functional grade level) could be weighted and summed in order to obtain the best possible prediction of performance on the Test of Natural Phenomena for the samples in question. From the analysis the researcher was also able to obtain statistics that indicated how accurate the equation was and how much of the variation in hierarchical classification ability was accounted for by the linear influences of age, sex, IQ, and functional grade level.

Path Analysis. In an attempt to further define the relationship between the predictor variables and hierarchical classification ability, path analysis was employed. Path analysis is an extension of regression analysis which attempts to specify a closed system of variables arranged so as to indicate a causal relationship between the variables. Each variable is determined completely by its specified causes and a residual variable. The path coefficients are typically presented as standardized partial regression coefficients. Residuals are error terms that account for the variance unexplained by the specified causes of a given variable. Table VI, page 69, presents the path coefficients of path analyses conducted on all subjects, adults and non-adults.

Figures 4-6 present the resulting path models for all subjects, adults and non-adults, in the form of path diagrams.

The variable test was used in these path analyses as the dependent variable, hierarchical classification ability. The correlation matrix presented in Table IV gives the correlation between test and level as being at or above .98. Although both test and level are highly correlated, and are both good measures of hierarchical classification ability, test was used in the path analyses because it is a slightly more sensitive measuring scale than level.

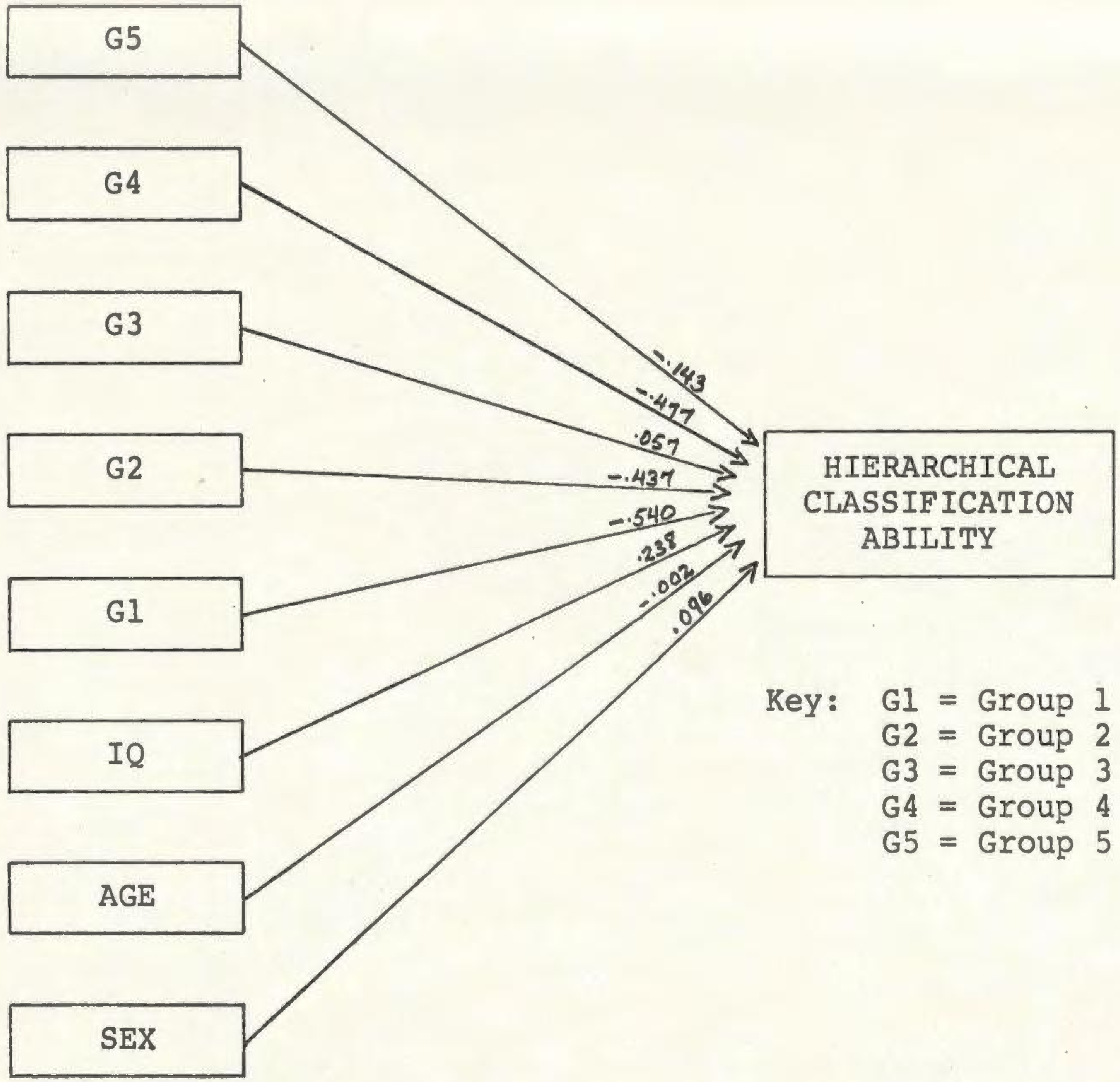
TABLE VI

Path Coefficients

	Dependent Variable (effect)	Independent Variables (causes) G5	G4	G3	G2	G1	IQ	Age	Sex	Residual*
All Subjects	Hierarchical Classification Ability	-.143	-.477	.057	-.437	-.540	.238	-.002	.096	.515
Adults	Hierarchical Classification Ability	-	-	-	-.594	-.680	.266	-.028	.096	.450
Non-adults	Hierarchical Classification Ability	-.209	-.696	-	-	-	.196	-.239	.100	.683

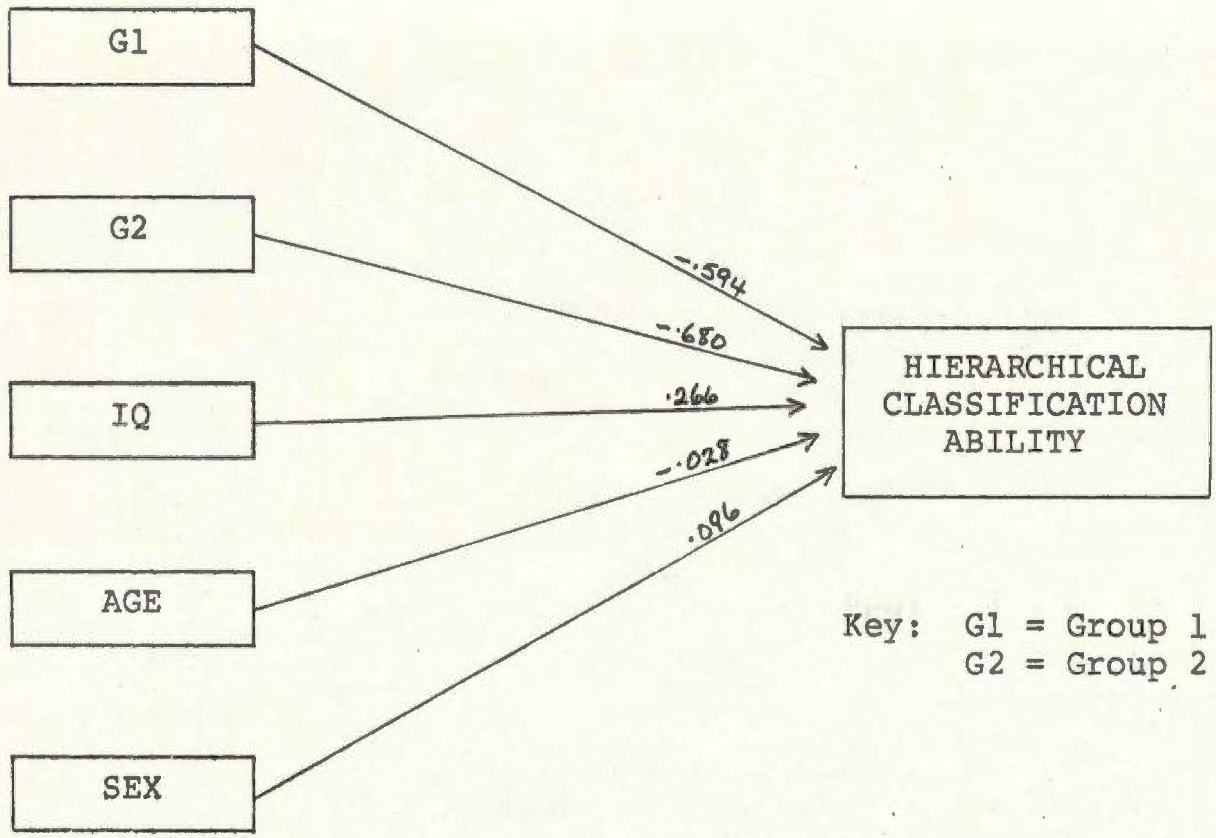
Key: G1 = Group 1
G2 = Group 2
G3 = Group 3
G4 = Group 4
G5 = Group 5

*The residual indicates the effects of variables outside the system on the dependent variable.



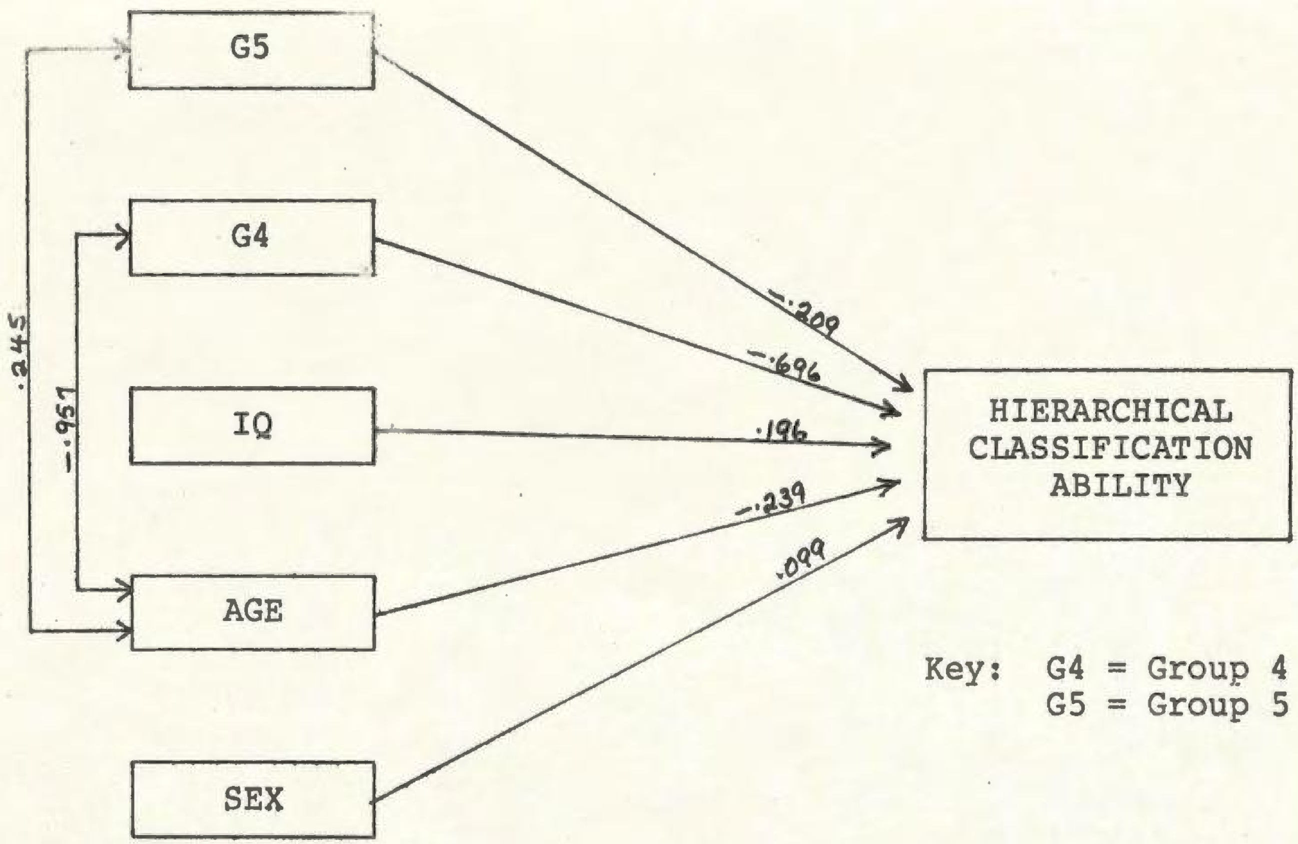
Note: G6 was constrained to zero. The inclusion of all dummies created from the given nominal variable would render the equation unsolvable because the κth dummy variable is determined by the κ-1 dummies entered into the regression equation.

FIGURE 4. Path Model of the Development of Hierarchical Classification Abilities in All Subjects.



Note: G3 was constrained to zero.

FIGURE 5. Path Model of the Development of Hierarchical Classification Abilities in Adults.



Note: G6 was constrained to zero.

FIGURE 6. Path Model of the Development of Hierarchical Classification Abilities in Non-Adults.

All Subjects:

Figure 4 shows that group membership, as defined by functional grade level, has the single most important influence on determining hierarchical classification ability. In the production of path coefficients for κ groups the inclusion of the κth group in the calculation would render the solution mathematically impossible; therefore it is necessary to hold the κth group constant. When Group 6 was constrained to zero membership in Groups 1, 2, 4, and 5 had a strong to moderately strong negative effect (-.540, -.437, -.477, -.143) on hierarchical classification ability. Membership in Group 3, however, had a weak positive effect (.057) on hierarchical classification ability. Next to group membership IQ is a strong determinant of hierarchical classification ability, with a strong positive effect of .238. The direct effect of sex (.096) is weak and the effect of age (-.002) is negligible. Figure 7, page 74, shows that these variables (age, sex, IQ, and functional grade level) accounted for 48.5% of the variance in the hierarchical classification abilities of all subjects.

Adult Subjects:

Figure 5, in presenting the path diagram for adult subjects, again shows that group membership is the single most important influence on hierarchical classification ability. When Group 3 was constrained to zero membership in

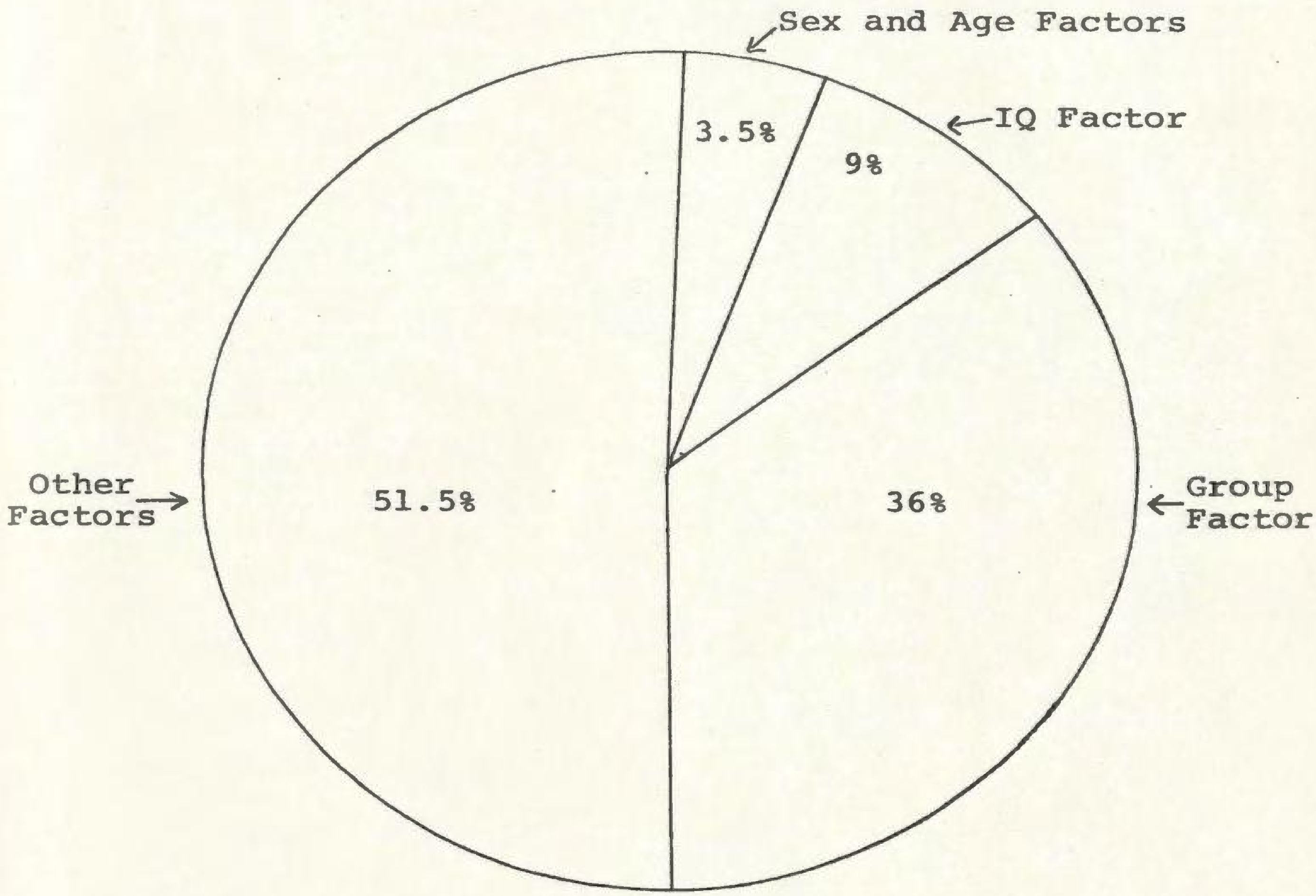


FIGURE 7. Percentage of Variance in Hierarchical Classification Abilities Accounted for in All Subjects

Groups 1 and 2 had a strong negative effect (-.594, -.680) on hierarchical classification ability. IQ again plays a strong positive role (.266) in the hierarchical classification ability of adult subjects. In the case of adult subjects the effect of sex (.096) is weak, with the effect of age (-.028) negligible. Figure 8, page 76, shows that these four variables account for 55% of the variance in the hierarchical classification abilities of adult subjects.

Non-adult Subjects:

The path diagram of non-adult subjects, Figure 6, page 72, shows a high inter-correlation among the predictors, age and group. This is probably explained by the fact that within schools a criterion for grouping is age. The high inter-correlation between age and group caused problems in the original analysis with standard error due to multiple collinearity. The problem of multiple collinearity was the reason for running another path analysis omitting age to test for the overall group effect. In the original path analysis age had a strong negative effect (-.239) on hierarchical classification ability. When age was omitted from the analysis and Group 6 was again constrained to zero, membership in Groups 4 and 5 had a strong negative effect (-.696, -.209) on hierarchical classification ability. However, with respect to the independent variables, IQ and sex, we note that in the case of non-adults, IQ had a moderately

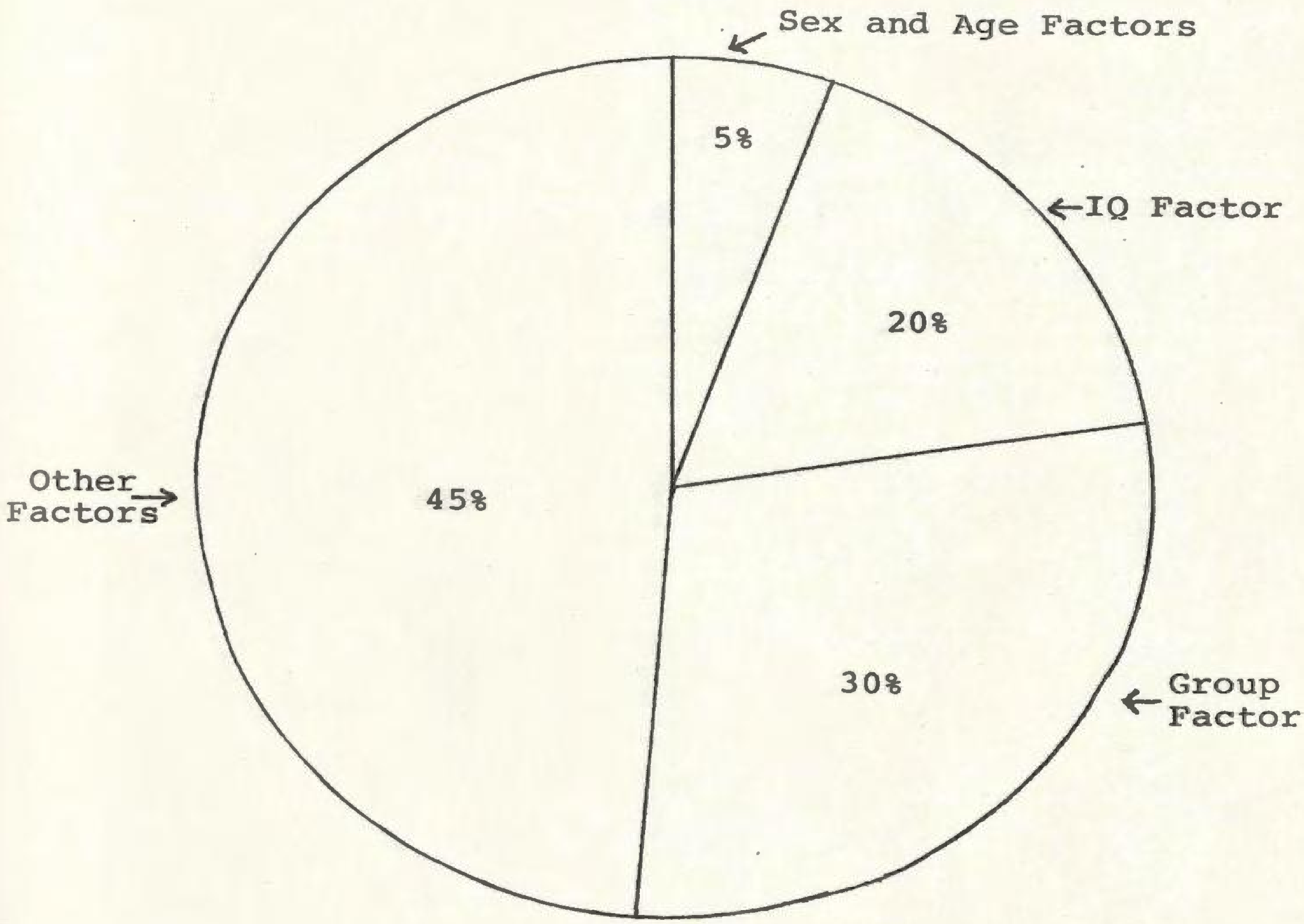


FIGURE 8. Percentage of Variance in Hierarchical Classification Abilities Accounted for in Adult Subjects.

strong positive effect (.196), with sex having a weak positive effect (.100) on classification ability. Figure 9, page 78, shows that the variables, group, IQ, and sex account for 33.7% of the variance in performance on Test of Natural Phenomena of non-adult subjects. The original path analysis showed that age alone accounted for 27.9% of the variance but since age is highly correlated with group age does not account for anything beyond what the variable group does.

Collinearity Between Age and Group in the Non-Adult Subjects:

Collinearity refers to the situation in which some or all of the independent variables are highly correlated. This situation can cause problems in regression analysis because (1) regression coefficients cannot be uniquely determined--that is, there is too much overlap, and (2) if extreme collinearity exists (for example, zero-order relationships in the 0.8 to 0.99 range) it may not be possible to invert the correlation matrix of the independent variables--the procedure upon which unique solutions to regression equations depends. This, in effect, means that the greater the inter-correlation of independent variables, the less the reliability of the relative importance indicated by the partial regression coefficients.

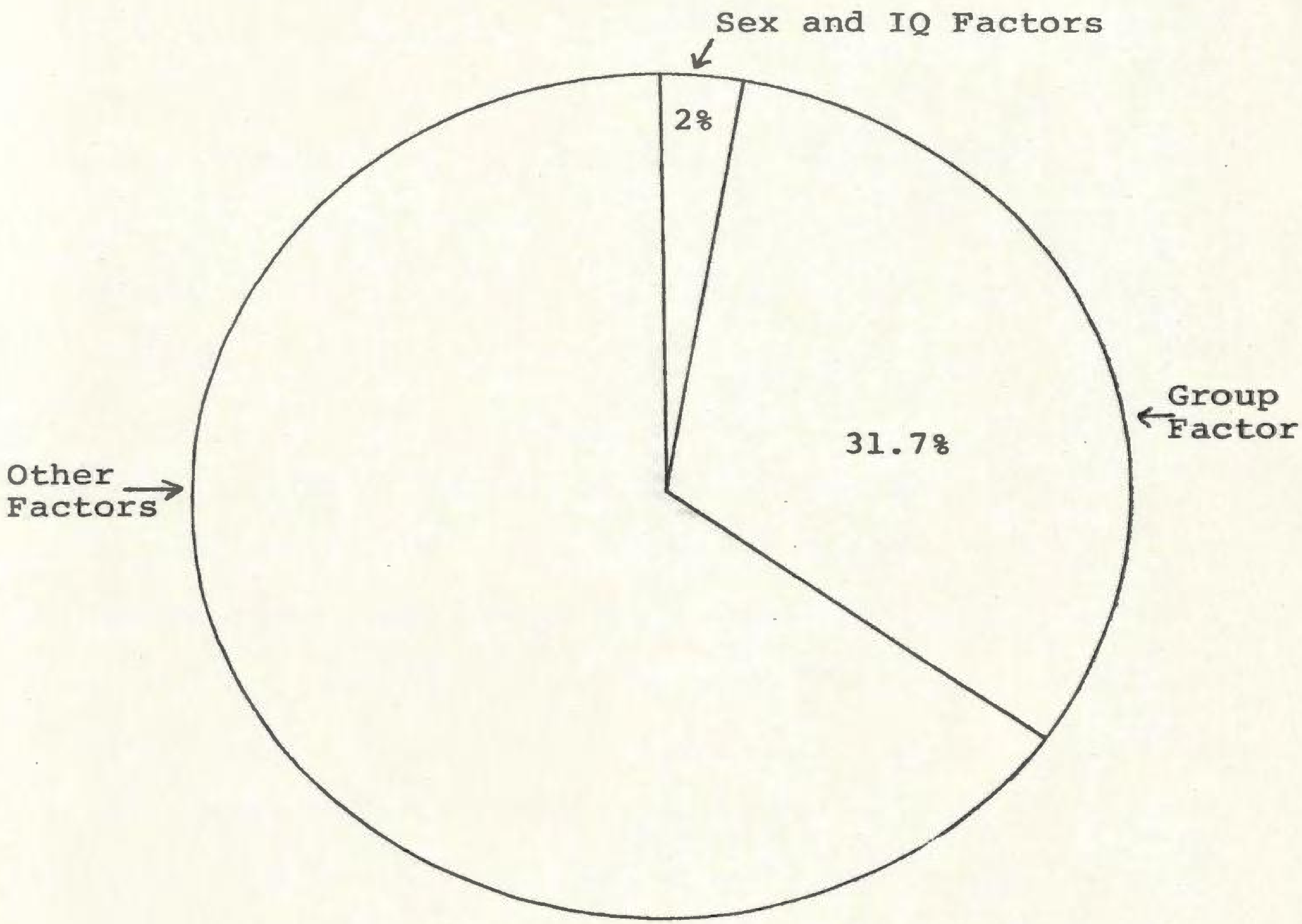


FIGURE 9. Percentage of Variance in Hierarchical Classification Abilities Accounted for in Non-Adult Subjects.

The correlation coefficients between age and Groups 4 and 5 were -.95, and .25, respectively, which was rather high in comparison to all other correlation coefficients between independent variables. This suggests that these two variables are highly interrelated; hence, they represent the same measure. In an attempt to solve the collinearity problem the path analysis of non-adult subjects was run, omitting age to allow for the effect of grouping to come through.

Coefficients of Determination. No matter what variable is used as X in the prediction equation, the square of the correlation (r) between the predictor variable and the criterion variable is referred to as the coefficients of determination. This indicates the proportion of variance among the criterion scores that can be explained by differences in the predictor variable or that a given percentage of Y variance is predictable on the basis of the set of predictor variables.

Tables VII to IX outline the proportion of variance in hierarchical classification ability explained by the independent variables in the analysis of variance of hierarchical classification ability of all subjects, adults and non-adults. This gives an indication of the predictability of the independent variables that were considered in this study. An examination of Figures 7 to 9 will give the

TABLE VII

Predictability of Variables (All Subjects)

Independent Variables	R^2	100 R^2	F	P
Sex	.003	0.3	0.49	N.S.
Age	.036	3.6	3.27	< .05
IQ	.127	12.7	8.51	< .01
Group 1	.229	22.9	12.93	< .01
Group 2	.351	35.1	18.69	< .01
Group 3	.375	37.5	17.22	< .01
Group 4	.481	48.1	22.62	< .01
Group 5	.493	49.3	20.65	< .01

TABLE VIII

Predictability of Variables (Adults)

Independent Variables	R^2	100 R^2	F	P
Sex	.002	.2	0.15	N.S.
Age	.055	5.5	2.50	N.S.
IQ	.254	25.4	9.66	< .01
Group 1	.322	32.2	9.96	< .01
Group 2	.560	56.0	21.12	< .01

TABLE IX

Predictability of Variables (Non-Adults)

Independent Variables	R^2	100 R^2	F	P
Sex	.017	1.7	1.54	N.S.
Age	.296	29.6	18.27	< .01
IQ	.330	33.0	14.15	< .01
Group 4	.339	33.9	8.61	< .01
Group 5	.331	33.1	10.49	< .01

percentage of variance explained by these variables.

From the F ratios presented in Tables VII to IX a level of significance is given for each of the independent variables. When all subjects were included in the regression analysis, group and IQ were significant at $p < .01$; age was significant at $p < .05$; and sex was insignificant. This finding held true for non-adult subjects except age played a stronger role. It was significant at $p < .01$. For adult subjects group and IQ were again significant at $p < .01$ but age and sex were insignificant.

It should be noted that the pattern of results presented by the coefficient of determination for each of the independent variables is consistent with that presented in the path analysis. That is, coefficients of determination for each of the independent variables are calculated and used in determining path coefficients for these variables within the path analysis.

Summary of Findings in Relation to Hypotheses

The purpose of this section is to discuss the findings of this study in terms of the extent to which such findings support or reject the hypotheses. Since the pattern of the findings of the correlation analysis is consistent with the findings of the regression analysis this summary will discuss only the findings of the regression analysis. An additional argument for doing so is the fact that multiple regression subsumes the correlation matrices in the calculation of the beta weights for the predictor variables.

The procedure for selection or rejection of hypotheses used here is consistent with the conventional format used in analysis of variance. However, since multiple regression is a more powerful measure than a straight analysis of variance the results of the multiple regression not only provide a significance level for the effect of each variable but it also gives the percentage of variance (Tables VI to IX) explained by each independent variable.

Hypothesis 1A: The age of a subject will affect his performance on the test of abstract learning ability. An older subject should perform better than a younger subject.

The standardized beta for the effect of age on the hierarchical classification ability of non-adults was .239 which was significant at $p < .01$. Therefore, Hypothesis 1A was accepted which indicated that after standardizing all the variables, then controlling the effect of age the predictor variable, age, had a strong effect on hierarchical classification ability of non-adults.

For adult subjects the standardized beta for the effect of age on hierarchical classification ability was -.028 which was not significant, using an acceptable significance level of $p < .05$. It was therefore concluded that age does not significantly affect the hierarchical classification ability of adult subjects.

Hypothesis 1B: The performance of adult subjects should be superior to that of non-adult subjects.

An examination of the standardized beta weights in Figure 4, page 70, and Table II, page 57, shows that the performance of the adult Groups 1 and 2 was not superior to comparable non-adult Groups 4 and 5. However, the performance of adults in Group 3 was slightly superior to the comparable non-adult Group 6, with a standardized beta of .057. This finding was significant at $p < .01$. Since the performance of adult subjects was only superior to the performance of non-adult subjects in one instance this is not strong support for the hypothesis. Therefore, it is rejected.

Hypothesis 2: The sex of a subject will not affect the subject's performance on the test of abstract learning ability.

The standardized betas for the effect of sex on hierarchical classification ability of adult and non-adult subjects were .096, and .100 which were not significant at

$p < .05$. The hypothesis is therefore accepted.

Hypothesis 3: On the test of abstract learning ability the performance of subjects of high IQ will be superior to those of low IQ.

The standardized betas for the effect of IQ on the hierarchical classification ability of adult and non-adult subjects were .266, and .106 which were both significant at $p < .01$. The hypothesis is therefore accepted.

Hypothesis 4: The higher the functional grade level of the subject the better the performance of that subject on the test of abstract learning.

An examination of the standardized beta weights in Figures 5 and 6, as well as Table II, shows that as the functional grade level of both adult and non-adult subjects increases so does their ability to classify.

Functional grade level was entered into the regression analysis as dummy variables. Therefore, all functional grade levels were given a beta weight. For adult subjects when Group 3 (functional grade level $\geqslant 11$) was constrained to zero, Group I (functional grade level 4) and Group 2 (functional grade level 9) had standardized betas of -.680, and -.594. That is, as the functional grade level decreased so did hierarchical classification ability, or vice-versa as functional grade level increased so did hierarchical classification ability. With respect to non-adult subjects when Group 6 (functional grade level $\geqslant$ 11) was constrained to zero, Group 4 (functional grade level 4) and Group 5 (functional grade level 9) reported standardized betas of -.696, and -.209. These beta weights not only indicate that the functional grade level was significant at $p < .01$ but that it was significant for both adult and non-adult subjects. The beta weights were negative because the highest functional grade level was chosen as the dummy variable to be constrained. However, had the lowest functional grade level been constrained the beta weights would have been positive. The hypothesis is therefore accepted.

Part II: Reliability and Validity of Instrument

The three most widely used techniques for establishing instrument reliability are (1) test-retest, (2) parallel forms, and (3) split half method. In this study only a modified version of the test-retest technique was possible because there is no parallel form of the Test of Natural Phenomena, and the fact that the test is an hierarchical test does not allow for the use of the split half method.

The criterion for instrument reliability used in this study was that group performance be identical or similar to the performance of comparable groups in studies reported elsewhere on the particular instrument under consideration in this study. Figures 10 to 12 give the results of graphs constructed to show the average cumulative trials to criterion versus level of abstraction for the three non-adult groups included in this study with comparable groups reported in studies by Lowell. These graphs show that non-adult subjects of the same approximate age range in both Lowell's studies and the present study have similar or identical hierarchical classification ability.

The researcher was unable to compare the performance of the three adult groups with comparable adult groups in previous studies because as of yet no other adult groups have been tested on the Test of Natural Phenomena. However, an examination of Figure 13 reveals that performance of adults and non-adults of the same functional grade level is comparable.

Table X, page 93, displays the percentage of anomalous behavior reported in the six groups included in the study. It should be noted that in dealing with human behavior anomalies or inconsistencies in performance are expected. In this study anomalies occurred when subjects failed lower levels and then passed higher levels, or sporadically passed or failed levels all the way up the hierarchy. Widely occurring performance of this sort would invalidate the hierarchical test; however, in the six groups included in this study the percentage of subjects demonstrating predictable

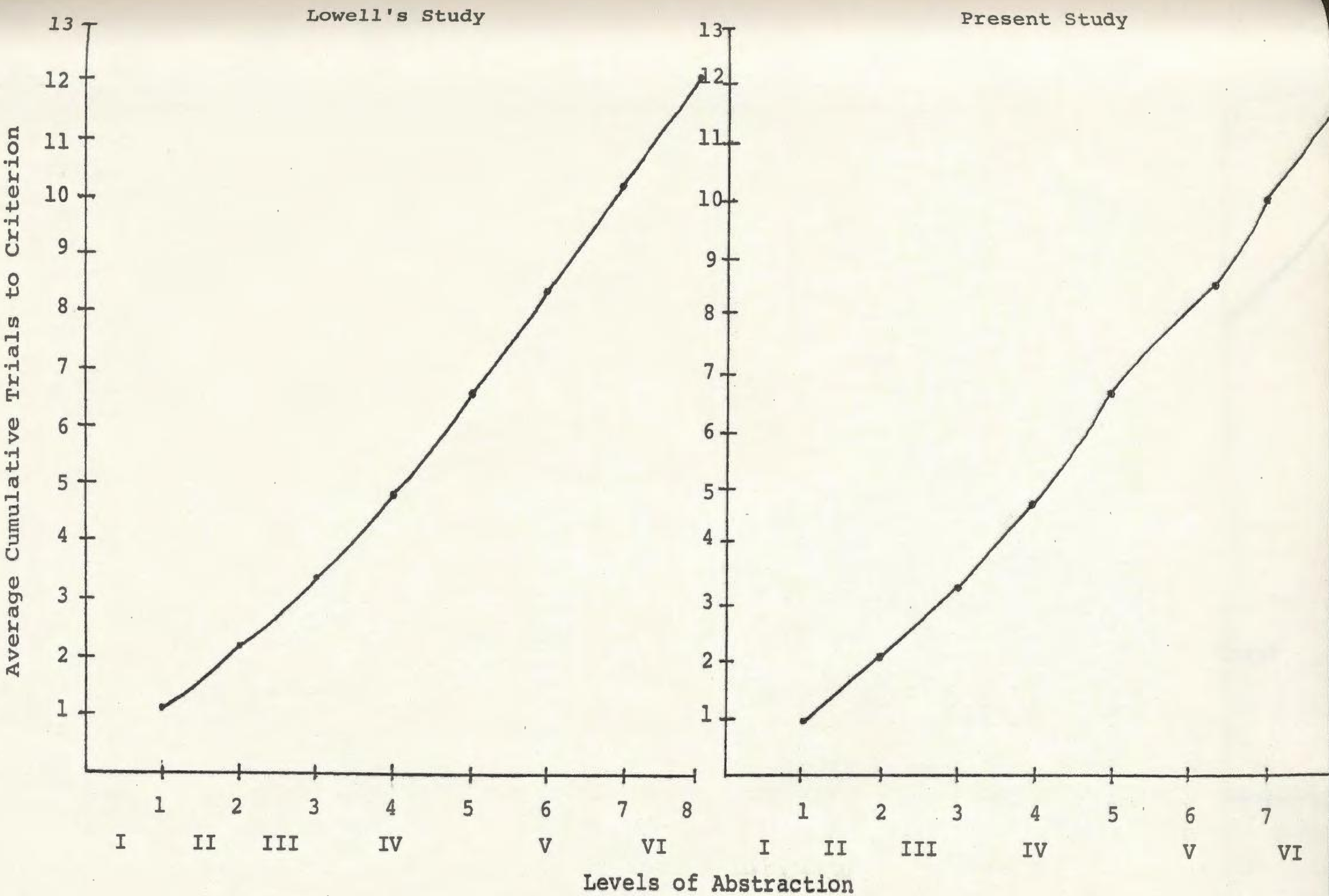
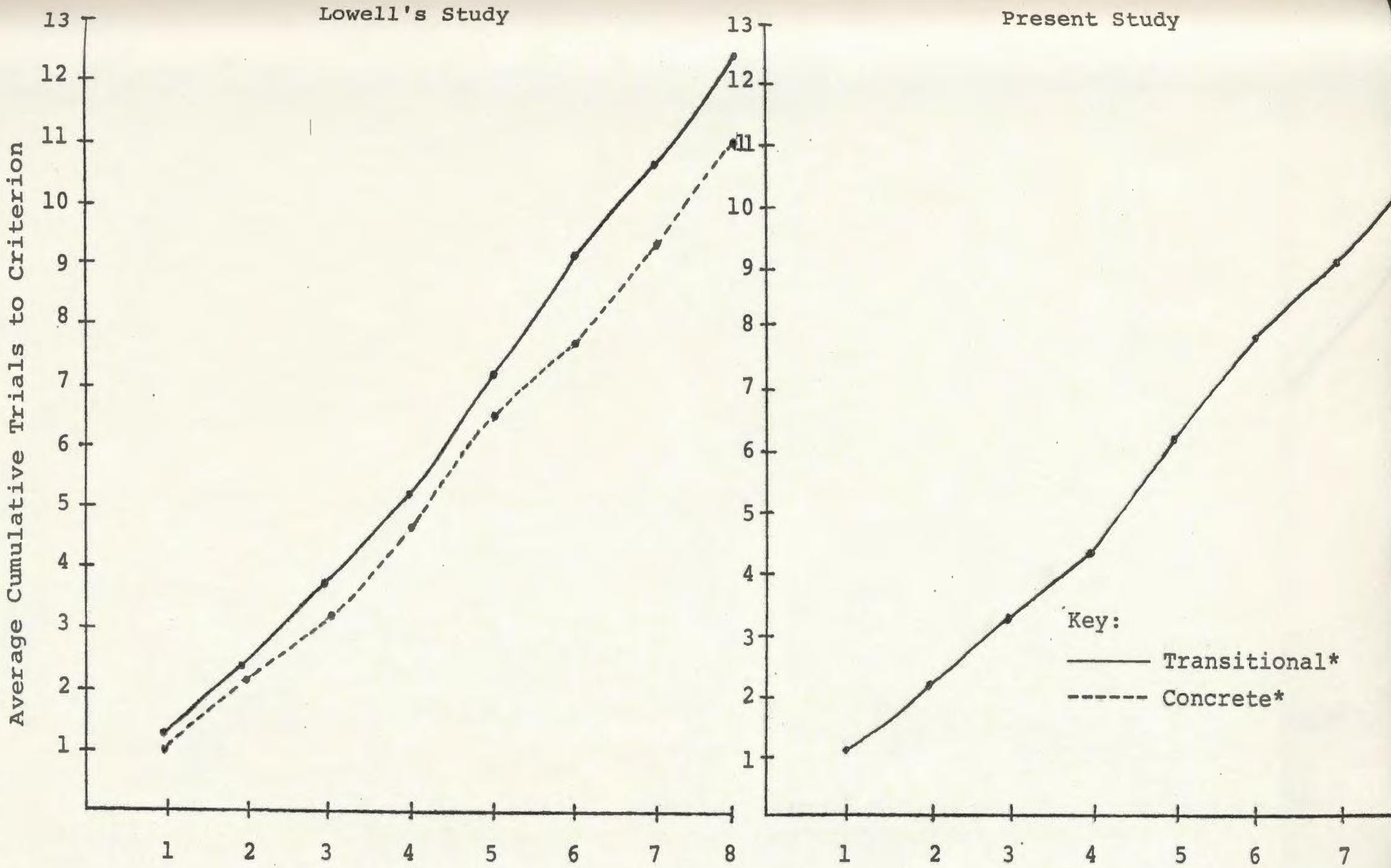
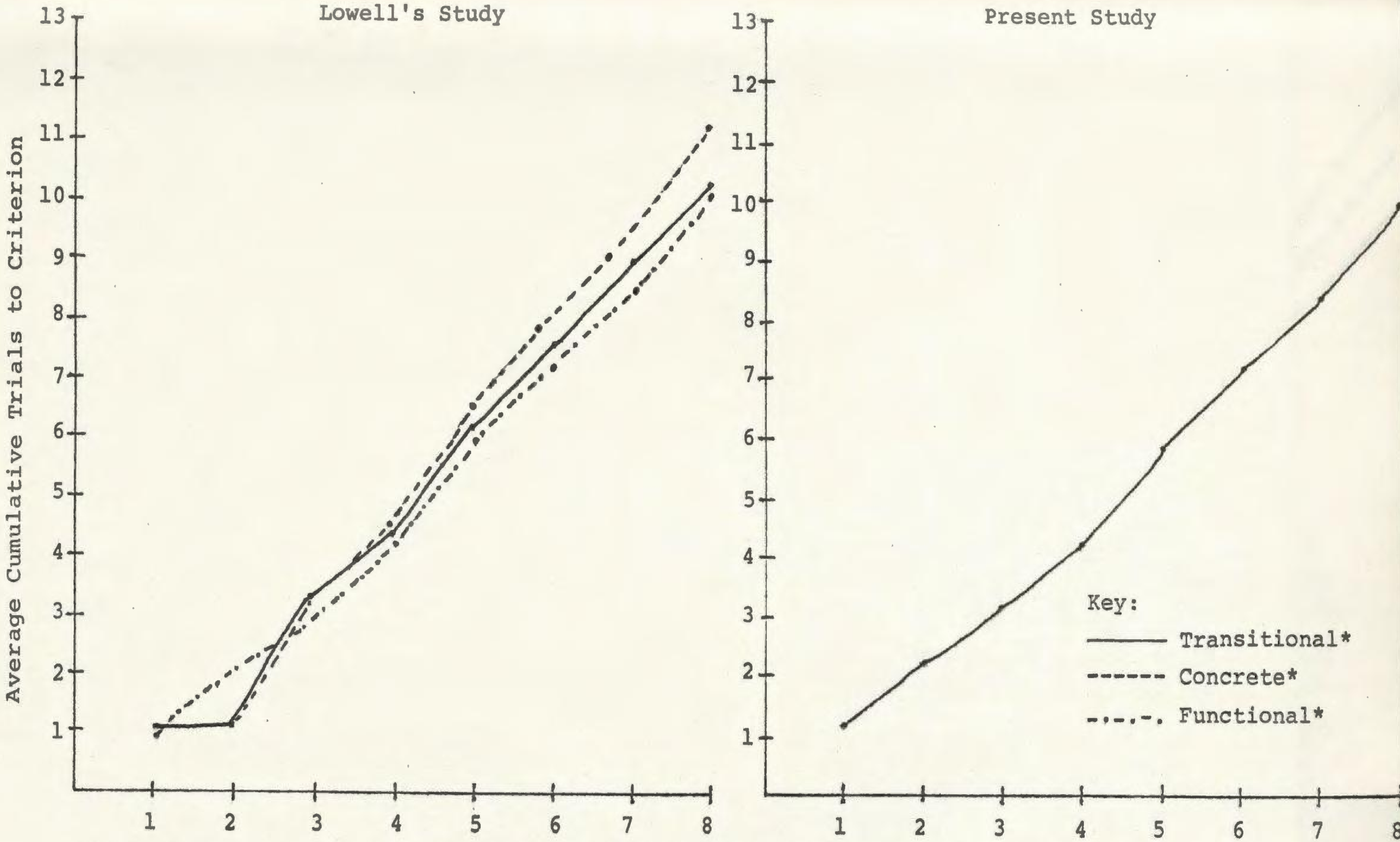


FIGURE 10. A Comparison of Average Cumulative Trials to Criterion Versus Level of Abstraction of Non-Adult Group IV With a Comparable Non-Adult Group



*Piagetian levels of development as defined in Lowell's second study.

FIGURE 11. A Comparison of Average Cumulative Trials to Criterion Versus Level of Abstraction of Non-Adult Group V with a Comparable Non-Adult Group



*Piagetian levels of development as defined in Lowell's second study.

FIGURE 12. A Comparison of Average Cumulative Trials to Criterion Versus Level of Abstraction of Non-Adult Group VI with a Comparable Non-Adult Group

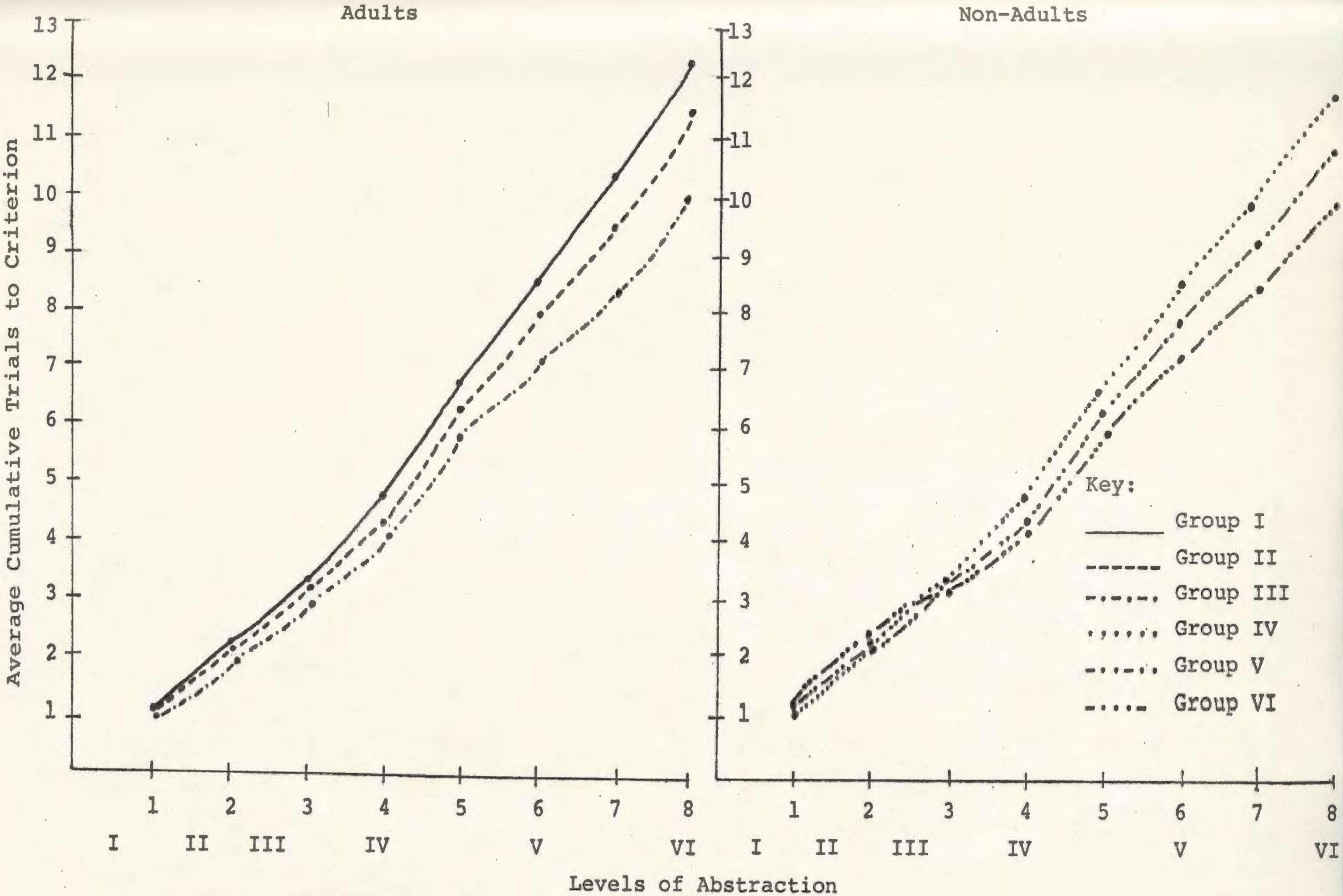


FIGURE 13. The Average Cumulative Trials to Criterion Versus Level of Abstraction of Adult and Non-Adult Groups

TABLE X

Percentage of Anomalous Behavior for All Groups

Group		# Ss Anomalous	% Anomalous
1	42	2	4.76
2	33	1	3.03
3	30	2	6.66
4	30	3	10.0
5	30	4	13.33
6	30	1	3.33
Total	195	13	6.67

Group 1 = Adults of Functional Grade Level < 5

Group 2 = Adults of Functional Grade Level $5 < x \leq 11$

Group 3 = Adults of Functional Grade Level ≥ 11

Group 4 = Non-adults of Functional Grade Level < 5

Group 5 = Non-adults of Functional Grade Level $5 < x \leq 11$

Group 6 = Non-adults of Functional Grade Level ≥ 11

behavior on the hierarchical test was 86.66% to 96.97%. Similar findings were reported earlier in two studies by Lowell who found that 82.6% and 88.91% of subjects in these studies demonstrated predictable behavior on the hierarchical classification test.

Support for the validity of the Test of Natural Phenomena is found in the results of the average cumulative trials to criterion taken by each of the six groups on the test. The average cumulative number of trials taken by each group for all eight tests provides evidence as to the amount of difficulty each group experienced with each level on the test. Since the Test of Natural Phenomena is supposedly an hierarchical scale then the average cumulative trials should increase as we go up the scale. An examination of Table III reveals that this is the case in this study. That is, the average cumulative trials to criterion increases as the level of difficulty on the test increases.

Further agrument for the validity of the Test of Natural Phenomena is the fact that the instrument was able to distinguish between adult and non-adult subjects of different functional grade levels. Table II shows the results of the performance of the adult and non-adult subjects on the Test of Natural Phenomena.

The results of this study indicate that substantial evidence has been obtained to support the assumption that the hierarchical classification test is a valid instrument.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Even though abstraction has been the subject of numerous investigations detailed knowledge of its nature and development is fragmented and poorly understood. Little research exists where the area of abstraction has been investigated through a systematic approach such as model building. This study explored a model of abstraction developed by W.E. Lowell. The model is based on the definition of abstraction as:

> the cognitive process of discriminating specific attributes of the environment that can be combined to form generalized representations which can take the form of classes, sets of relations, or operations.[66]

This study explored one dimension of the model of abstraction, hierarchical classification. Since the classification dimension had been explored in two earlier studies, this study attempted a more detailed examination of the influence

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[66] Walter Edward Lowell, "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects," (Doctoral Dissertation, Columbia University, New York, 1974), p. 3.

of the variables, age, sex, IQ, and functional grade level on performance on the abstraction measure, The Test of Natural Phenomena.

As an exploratory study, this study evaluated the performance of subjects from a variety of educational settings on the measure of abstract learning. Six classes, totalling 195 subjects comprised the sample. These six classes consisted of three classes of adults and three classes of non-adults categorized on the basis of their functional grade level.

The Test of Natural Phenomena, an instrument designed to measure hierarchical classification ability was administered individually to all subjects included in the study. At that time information was also obtained on the independent variables, age, sex, IQ, and functional grade level. In the case of IQ data testing was alternated with the Test of Natural Phenomena. Path analysis was used to analyze the model of causal relations that were hypothesized as existing between the independent variables and hierarchical classification ability. The conclusions of this analysis are set forth below.

Conclusions

The conclusions of this study are drawn from the findings of Chapter IV and the theoretical and practical implications that arose from those findings. The conclusions are summarized as (1) theoretical conclusions, (2) practical conclusions, and (3) recommendations for extending the research.

Theoretical Conclusions

Essentially this study attempted to answer four fundamental questions: To what extent do the variables, age, sex, IQ, and functional grade level affect a subject's hierarchical classification ability (as measured by The Test of Natural Phenomena)? In an attempt to answer these questions a model of causal relations was examined. In the findings, strong trends emerged which lead the investigator to conclude as follows.

Model of Causal Relations

Functional grade level and hierarchical classification ability. Grouping emerges as the most significant factor in the model for explaining hierarchical classification ability. Group membership was determined by functional grade level and is a powerful predictor of hierarchical classification ability. It is independent of age, sex, and IQ and operates over and beyond all other variables. However, in non-adult subjects the effect of group membership is very hard to ascertain due to the intervening of the variable, age. This is due to the fact that subjects in the non-adult groups are within a limited age range. This is evidenced by the fact that correlation between age and group is .95. The high inter-correlation between age and group causes collinearity problems in multiple regression analysis. The removal of age from the analysis of non-adult hierarchical classification abilities allows for the effect of group membership to be analyzed. This is supported by the fact that when age is removed group emerges as the most significant factor in the model for explaining hierarchical classification ability of non-adults. Therefore, group membership is the most significant factor for explaining hierarchical classification ability of adults and non-adults but in the case of non-adults it must be recognized that age and functional grade level are both measures of group membership.

The finding that group membership, as determined by functional grade level, can determine hierarchical classification ability suggests that schooling may be an important factor in determining hierarchical classification ability. Such a finding also lends support to the proponents of the theory of the importance of schooling in determining hierarchical classification ability. This theory has been advanced by such people as Lorge, Piaget, Vinacke, Kendler, Stein and Susses, and Lowell.

The hypothesis presented earlier in this study that the higher the functional grade level of the subject the better the performance of that subject on the test of abstract learning ability is well supported in the results of this study. In the case of both adult and non-adult subjects it was found that as the functional grade level of the subject increased so did the performance of that subject. It was also found that the performance of adult subjects with the exception of Group 3 (functional grade level $\geqslant 11$) was no better than that of the non-adult subjects in this study. This seems to indicate that schooling is more important than age in determining hierarchical classification ability. That is, age alone is not a good determinant of hierarchical classification ability. Clearly, these findings point to the importance of schooling in determining hierarchical classification ability.

IQ and hierarchical classification ability. The hypothesis presented earlier, that the higher the IQ of a subject the better the performance of that subject on the test of abstract learning ability is well supported in this study. When all subjects are included in the model of causal relations it was found that IQ is a strong determinant of hierarchical classification ability. However, when we consider adults and non-adults separately it was found that IQ is even a stronger determinant of hierarchical classification ability in adults than it is in non-adults.

The fact that IQ had a stronger effect on the hierarchical classification ability of adults than non-adults might be attributable to the different environmental exposures of both groups. The educational setting of the non-adult subjects might better develop hierarchical classification skills for subjects of all ability levels whereas the exposure to skills which demand hierarchical classification might not be present in the educational setting of the adult subjects. There is some evidence to suggest that this might be particularly true of the adults in Group 1. Students in Group 1 were enrolled in a Basic Literacy Program which did not include science. Science has been recognized as a course which usually aids in the development of such skills as hierarchical classification. Since Group 1 constituted 42 of 105 adult subjects tested the above argument offers a possible explanation.

It must also be acknowledged that in the case of adult Groups 1 and 2 that a different IQ measure was used. Although an attempt was made to eliminate any discrepancy that might occur as a result it still must be recognized that part of the noted difference in the influence of IQ on the hierarchical classification ability of adults might be attributed to the type of IQ measure.

In conclusion, it is noted that the findings of this study that IQ plays a strong role in determining hierarchical classification ability is consistent with the findings of

Clark and others presented earlier. It is also taken to be some support for the argument that hierarchical classification ability is a dimension of intelligence.

Age and hierarchical classification ability. Age is not a strong determinant of hierarchical classification ability when all subjects are included in the causal model. While this finding holds true for adults it does not hold in the case of non-adults where age has a significant effect. As noted earlier this is probably accounted for by the fact that within schools a criterion for grouping is age. Therefore, in respect to non-adults there is support for the hypothesis that as age increases so does the ability to classify. Adults, however, deviate from this pattern, in fact an inverse relationship was found. That is, the younger adults performed better than older adults on the hierarchical classification test. Adult educators note that there is some evidence to suggest that aging in adults produces ability differences but research in this area is not conclusive.[67] Since this study was only concerned with young and middle aged adults then other factors (other than age), such as social and cultural factors, might account for differences in the performance of the adult subjects.

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[67] Huey B. Long, and Curtis Ulmer, eds., Are They Ever Too Old To Learn? (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., Prentice-Hall Adult Education Series, 1971), pp. 11-29.

The hypothesis that adult subjects would perform better than non-adult subjects is not supported in this study. It was noted in this study that for adults of functional grade levels 4 and 9 they did not perform as well as the non-adult subjects of comparable functional grade levels. Some possible explanations for such results are:

1. The fact that the adults in these two groups were of a mean functional grade level meant that there were some subjects within these adult groups that were not functioning at the mean functional grade level of their group.

2. The type of curriculum taught in the public school system might better equip subjects to cope with hierarchical classification tasks.

3. If it is recognized that subjects who have membership in these two groups have been educationally deprived at some point in their educational history then it must be acknowledged that this offers a possible explanation for their performance. Studies relating to educationally deprived subjects claim that when deprivation takes place there is often effects of this deprivation which are hard to overcome.[68,69]

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[68]Robert D. Hess, "The Latent Resources of the Child's Mind," Journal of Research in Science Teaching, I, No. 1 (1963), pp. 20-26.

[69]Donald Olding Hebb, A Textbook of Psychology (Philadelphia: W.B. Saunders Company, 1968), p. 97.

In consideration of the performance of adults of functional grade level 11 it is noted that they performed as expected. That is, the performance of this group was superior to that of the non-adult subjects of the same functional grade level. Therefore, it can be concluded that if a subject is of an adult status it will not necessarily make his performance inferior. That is, there are other factors (other than age) that must be taken into consideration. In the case of adult subjects of functional grade level 11 it is noted that this group did not have an interrupted academic program as did the other two adult groups. This factor alone offers a plausible explanation for the superior performance of adults of functional grade level 11.

The explanation of hierarchical classification ability in adult subjects is undoubtfully a complex issue. This issue is further compounded by the fact that very little research has been conducted on the cognitive abilities of adult subjects, particularly deprived subjects.[70] Nevertheless, it must be acknowledged that with respect to hierarchical classification ability, the performance of adult subjects (with the exception of Group 3) was not superior to that of comparable non-adult groups. This finding suggests that there must be other factors other than IQ, age, and group status that must be taken into consideration when predicting

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[70]Angelica W. Cass, Basic Education for Adults (New York: Association Press, 1971), pp. 29-31.

the hierarchical classification ability of such subjects.

Sex and hierarchical classification ability. This study has found that sex is not a strong determinant of hierarchical classification ability. This finding is particularly true of non-adults. However, with respect to adults it is a stronger determinant than age. Nevertheless, the relationship is not strong enough to disprove the hypothesis that sex will not affect hierarchical classification ability. Therefore, the finding that sex does not significantly affect hierarchical classification is in total agreement with other research findings in this area.[71]

Model of Abstraction

As an exploratory study, the results of this study provided further evidence that the model of abstraction and the test based on that model can be considered a reliable and valid indication of cognitive ability. Evidence has been obtained that the ability to organize information in hierarchical arrays is dependent upon the functional grade level of the subject. Individuals at low functional grade levels demonstrate less ability to perform hierarchical

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[71] D.C. Clark, "Teaching Concepts in the Classroom: A Set of Teaching Prescriptions. Derived from Experimental Research," Journal of Educational Psychology, LXII, No. 3 (1971), p. 239.

classification tasks. The validity of the test is further supported by the fact that the large percentage of subjects who failed lower levels on the test went on to fail higher levels. This study has yielded strong support for the hierarchical test and the model on which it is based.

Practical Conclusions

Given the theoretical conclusions of this study the following practical conclusions emerge:

1. The results provide suggestions to educators on methods of how to facilitate abstract learning in various groups. Since functional grade level is a strong determinant of hierarchical classification an increase in functional grade level would also mean an increase in abstract learning ability. This suggests that educators concentrate on methods of raising the functional grade level of various groups. Such work would not only be a valuable contribution to the general education of such groups but would also help to increase their abstract learning ability.

2. The results of this study also show the utility of The Test of Natural Phenomena as a diagnostic tool to collect information on the hierarchical classification abilities of various groups. The present investigation has shown that the Test of Natural Phenomena is an excellent instrument for determining group membership (as defined by functional grade level). The instrument is a powerful

instrument in that it does differentiate between the hierarchical classification ability of subjects of different functional grade levels.

3. The results of this study offer some practical suggestions for curriculum development. The data collected on the various groups provides useful information as to the level of abstraction that such groups are capable of performing. The findings of this study are particularly useful with respect to adult groups because of the lack of research on the cognitive abilities of adult subjects.

Recommendations for Further Research

The general model of analysis developed in this study attempted to integrate some of the correlates of hierarchical classification ability into a theoretically meaningful causal scheme. It specified only a limited number of relationships, and as such could be made the subject of further research. A study might be designed including other exogenous and intervening variables that might make a significant contribution to the dependent variable, hierarchical classification ability. Such variables (measures of which were not included in this study) might include science aptitude, and developmental level.

Although the causal models presented in this study account for 33.7% to 55% of the ability to classify, 45 to

66.3% of the variance in hierarchical classification ability is accounted for by variables outside the system. An examination of these other variables is a subject for further research.

An awareness and understanding of hierarchical classification abilities of various groups is a problem facing educators and curriculum developers in the area of Science Education. Their decision-making would tend to be more fruitful if based on factual knowledge. Commenting on this issue Lowell notes that abstraction and hierarchical structures have recently been the focus of much research and curricula emphasis in Science Education.[72] His rationale for the development of the model of abstract learning was to provide a systematic theoretical framework for further studies in this area. Since this study has shown that the functional grade level of a subject is a strong determinant of hierarchical classification ability of adult and non-adult subjects, then research should be extended to cover all possible functional grade level. Such research would result in the creation of norms for hierarchical classification ability. This would be useful as a diagnostic tool for the measurement of hierarchical classification ability. In addition, this

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[72] Walter Edward Lowell, "An Empirical Study of a Model of Abstract Learning," Science Education, LXI, No. 2 (1977), p. 229.

would provide a broader data base for curriculum development in such areas as science education.

The classification hierarchy explored in this study is only one dimension of the model of abstract learning ability. Research into the model should be extended to include the other dimensions proposed by Lowell. These dimensions should be developed and explored by causal models as presented in this study. In addition, alternate forms of the Test of Natural Phenomena should also be developed and explored.

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APPENDIX A

TEST OF NATURAL PHENOMENA

TESTING PROCEDURE FOR NATURAL PHENOMENA

Instructions to Subject

The examiner will sit facing the subject. The examiner will then read the instructions to the subject.

"Hello. My name is ________________. I am going to teach you a lesson in sicence, about things found in nature. I am going to show you something found in nature. After you have looked at it, I am going to take it away, and then have you find an object which looks like the one I showed you. Do you have any questions?"

If there are no questions, the examiner will begin.

Test One--Attribute Identification

The examiner will open the Attribute Identification Example Box and present to the subject a sample of galena and a sample or iron pyrite. The examiner will then say, "I want you to look at these two things." The subject will not be given the name of these two objects, since this task is primarily concerned with the subject's ability to discriminate specific attributes. The subject will be allowed to handle the objects. When the subject has finished looking at the specimens they will be placed back in the Attribute Identification Box and removed from sight.

The examiner will then present the Attribute Identification Test Box. The test box will contain the following materials:

Galena--(a different specimen)

Pyrite--(a different specimen)

Chalcopyrite

Mica

Granite

Orthoclase Feldspar

Galena and pyrite will be the correct instances to be selected, while mica, granite, chalcopyrite, and orthoclase feldspar will serve as distractors. These distractors were selected because each shares at least one attribute with galena and/or pyrite.

The examiner will open the Attribute Identification Test Box and say to the subject: "Okay, can you find any objects in this box which look like the ones I just showed you? You may handle the objects if you want to." The criterion for successful completion of the test will be correct identification of both instances. When the subject has made his response the examiner will ask, "Are you sure these are the ones you want?" If the subject responds "Yes" and he has met criterion stated above, the subject will go on to Test 2.

Failure to meet criterion for all tests will occur when the subject (a) fails to identify either instance, (b) only identified one instance correctly, or (c) identified both instances correctly, but placed one or more incorrect instances in the correct group. When the subject has failed to meet the criterion set forth above, the examiner will ask the subject, "Are you sure these are the ones you want?" If the subject responds "Yes," then the examiner will upon failure to meet criterion, the entire test will be given exactly as stated above. If the subject is unsuccessful on the second trial, the testing sequence will be continued. However, since the theoretical model of abstraction used in this study assumes that no higher-level abstraction can be learned until a corresponding lower abstraction has been learned, the subject will be given the next highest level. This procedure will be used as a check on the logical structure of the model of abstraction being used in this study. This procedure will be implemented whenever failure occurs on any test, with the exception of the last test.

Test Two--Attribute Recognition

Upon successful completion of Test One, Test Two--Attribute Recognition, will be given. The examiner will present to the subject the Attribute Recognition Example Box. The box will contain a specimen of galena and a specimen of pyrite. The examiner will open the box and say, "Now I would like you to look at these two objects. This is shiny and grey" (galena). The subject will be asked to repeat "shiny and grey," the two attributes to be tested, twice. The examiner will present the specimen of pyrite and say, "This is shiny and yellow." Again the subject will be asked to repeat twice the two attributes to be tested. When the subject is finished examining the specimens they will be placed back in the Attribute Recognition Example Box and removed from sight.

The examiner will then present to the subject the Attribute Recognition Test Box. The test box contains a specimen of galena, a specimen of pyrite, and four distractors (mica, orthoclase, pink granite, chalcopyrite). The examiner then opens the Attribute Recognition Test Box and asks, "Okay, now I want you to find any objects which look like the ones I showed you and tell me what I told you about them." The subject must select the correct instances and state the correct attributes to successfully pass the test. If the subject fails to meet criterion, the test will be repeated exactly as stated above. If the subject was unsuccessful on the second trial, the test will continue. Upon successful completion of Test Two, Test Three, Object Recognition, will be given.

Test Three--Object Recognition

The examiner will open the Object Recognition Example Box and present to the subject a specimen of galena and a specimen of pyrite. The examiner will then say, "This is lead and this is iron. Look at them carefully and tell me their names." The examiner will ask the subject to repeat the names twice. When the subject is finished examining the objects they will be placed back in the Object Regognition Example Box and removed from sight.

The examiner will then present the Object Recognition Test Box. The test box will contain the following materials:

Pyrite--(a different specimen)
Galena--(a different specimen)
Sandstone
Serpentine
Lodestone
Chalcopyrite

Galena and pyrite will be the correct instances to be selected. The distractors were selected because each shares at least one attribute with galena and/or pyrite.

The examiner will open the Object Recognition Test Box and say, "Now, I want you to find and name any objects which look like the ones I showed you." Criterion for this test will be the same as in Test One. Upon a correct response, the examiner will ask, "Are you sure they are the ones you want?" If subject's response is "yes," the subject has met the criterion. The procedure failing to reach criterion will be the same as in Test One.

Test Four--Level IV--Class Recognition

The examiner will open the Class Recognition Example Box (metallic) and present to the subject two objects, pyrite and magnetite. The examiner will then say, "Here are two objects which are metallic. Look at them carefully." The examiner will ask the subject to repeat twice the name metallic. When the subject has finished examining the objects they will be placed back in the Class Recognition Example Box and removed from sight.

The examiner will then present the Class Recognition Test Box (metallic). The test box will contain the following materials:

Galena

Chalcopyrite

Apatite

Granite

Sandstone

Obsidian

Galena and chalcopyrite will be the correct instances to be selected, while sandstone, apatite, granite, and obsidian will serve as distractors. Although the distractors may share at least one attribute with the correct instance, none of the distractors is metallic.

The examiner will open the Class Recognition Test Box and say, "Now, let me see you find the metallic object." Criterion for this test will be the same as in Test One. Upon a correct response, the examiner will ask, "Are you sure these are the ones you want?" If subject's response is "yes," the subject has met criterion and will continue on to Test Five. Failure to reach criterion will be the same as in Test One.

Test Five--Level IV--Class Recognition

The examiner will open the Class Recognition (non-metallic) Example Box and present to the subject two objects, kyanite and serpentine. The examiner will then say, "Here are two objects which are non-metallic. Look at them carefully." The examiner will then ask the subject to repeat the name non-metallic twice. When the subject has finished examining the objects they will be placed back in the Class Recognition (non-metallic) Example Box and removed from sight.

The examiner will then present the Class Recognition (non-metallic) Test Box. The test box will contain the following materials:

Granite
Mica
Galena
Chalcopyrite
Pyrite
Lodestone

Granite and mica will be the correct instances to be selected, while galena, chalcopyrite, lodestone, and pyrite will serve as distractors. Although the distractors may share at least one attribute with the correct instance, all of the distractors are metallic.

The examiner will open the Class Recognition (non-metallic) Test Box and say, "Can you find all the non-metallic objects for me?" Criterion for success will be the same as in Test One. Upon a correct response, the examiner will ask, "Are you sure these are the ones you want?" If subject's response is "yes," the subject has met criterion and will continue on to Test Six. Failure to reach criterion will be the same as in Test One.

Test Six--Level V--Class of Classes Recognition (Mineral)

The examiner will open the Class of Classes (mineral) Example Box and present its content, mica and malachite, to the subject. The examiner will then say, "Here are two objects which are minerals. Look at them carefully." The examiner will ask the subject to repeat the name mineral twice. When the subject has finished examining the objects they will be placed back in the Class of Classes Example Box and removed from sight.

The examiner will then present the Class of Classes (mineral) Test Box. The test box will contain the following materials:

Magnetite (Lodestone)
Microcline Feldspar
Wood
Plastic Cube
Steel Bar
Peanut

Pine Cone

Feather

Rubber Insect

Plastic Fruit

Plastic Flower

Toy Animal

The pine cone and the feather will be the correct instances to be selected, while the rubber insect, toy animal, plastic flower, and plastic fruit will serve as distractors.

The examiner will open the Class of Classes Recognition (Living Product) Test Box and say, "Find all objects which are Living Products." Criterion for success will be the same as in Test One. Upon a correct response, the examiner will ask, "Are you sure these are the ones you want?" If the subject's response is "yes," the subject has met criterion and will continue on to Test Eight. Failure to reach criterion will be the same as in Test One.

Test Eight--Level VI--Class of Classes Recognition (Natural Things)

The examiner will open the Class of Classes Recognition Example (Natural Things) Box and present its contents, a twig from a tree and a piece of sandstone, to the subject. The examiner will then say, "Here are two objects which are found in Nature, they are Natural Things. Look at them very carefully." The examiner will then ask the subject to repeat "Natural Things" twice. When the subject has finished examining the objects they will be placed in the Class of Classes Example Box and removed from sight.

The examiner will then present the Class of Classes Recognition (Natural Things) Test Box. The test box will contain the following materials:

Coal
Coral
Cork Stopper
Piece of Brick
Piece of Pottery
Piece of Chalk
Wooden Coffee Stirrers

The coal and coral will be the correct instances to be selected.

The examiner will open the Class of Classes Recognition (Natural Things) Test Box and say, "Find any objects in this box which look like Natural Things." Criterion for success will be the same as in Test One. Upon a correct response the examiner will ask, "Are you sure these are the ones you want?" If subject's response is "yes," the subject has met criterion and the testing is finished. Failure to reach criterion will be the same as in Test One. The subject will be given one additional trial to reach criterion upon failure in the first trial. Failure on both trials will terminate the test.

APPENDIX B

LEVELS OF ABSTRACTION

<u>Level I--Attribute Identification</u>

Example Materials:	Galena
	Pyrite (Fe)
Test Materials:	<u>Galena</u>
	<u>Pyrite</u>
	Mica
	Chalcopyrite
	Granite
	Orthoclase Feldspar

All minerals approximately 1" x 1" x 1"

Level II--Attribute Recognition

Example Materials: Galena

Pyrite

Test Materials: Galena

Pyrite

Mica

Chalcopyrite

Orthoclase Feldspar

Granite

All materials approximately 1" x 1" x 1"

<u>Level III--Object Recognition (Lead and Iron)</u>

Example Materials: Galena

Pyrite (Fe)

Test Materials: <u>Galena</u>

<u>Pyrite</u>

Chalcopyrite

Magnitite

Quartzite

Serpentine

All materials approximately 1" x 1" x 1"

<u>Level IV--Class Recognition (Metallic)</u>

Example Materials:	Pyrite (Fe)
	Magnetite (Lodestone)
Test Materials:	<u>Galena</u>
	<u>Chalcopyrite</u>
	Obsidian
	Apatite
	Granite
	Sandstone

All minerals approximately 1" x 1" x 1"

<u>Level IV--Class Recognition (Non-metallic)</u>

Example Materials:	<u>Kyanite</u>
	<u>Serpentine</u>
Test Materials:	(Granite, pink)
	<u>Mica</u>
	Galena
	Chalcopyrite
	Pyrite
	Lodestone

All minerals approximately 1" x 1" x 1"

<u>Level V--Class of Classes Recognition (Mineral)</u>

Example Materials: <u>Mica</u>

<u>Malachite</u>

Test Materials: <u>Magnetite</u>

Orthoclase Feldspar (pink)

Wood Drawer Handle

Flat Plastic Cube 1" x 2 " x 1/4"

Metal Key Ring

Peanut

All materials approximately 1" x 1" x 1"

<u>Level V--Class of Classes Recognition (Living Product)</u>

Example Materials: <u>Apple</u>

<u>Monarch Butterfly</u> (dried)

Test Materials: <u>Feather</u> (4" x 1") (pigeon)

<u>Pine Cone</u> (3" x 1")

Distractors: Rubber Insect

Toy Dog (to fit box)

Plastic Flower

Plastic Grapes

Level VI--Class of Classes Recognition (Natural Things)

Example Materials:

Twig (from a tree) 3"

Sandstone (grey) 1" x 1" x 1"

Test Materials:

Coal 1" x 1" x 1"

Coral 4" long (white)

1 Insulating Brick, broken (2" x 1" x 2", white)

1 Blackboard Chalk (slightly used)

1 Piece Broken Pottery (red)

3 Small Wooden Corks

3 Wooden Dowls (5" x 1/4")

3 Wooden Coffee Stirrers

APPENDIX C

SCORES HIGHEST LEVEL ACHIEVED

GROUP 1		GROUP 2		GROUP 3		GROUP 4		GROUP 5		GROUP 6	
3	5	3	4	6	6	5	3	5	3	6	6
3	3	5	3	6	6	5	6	3	6	5	5
3	4	3	3	6	5	3	2	5	3	4	6
3	3	3	3	5	6	3	3	6	6	6	3
3	3	3	3	5	6	3	3	5	4	6	6
3	3	4	3	6		3		6		4	
5	3	2	3	6		3		5		5	
0	6	3	3	6		3		4		6	
3	3	3		5		6		3		6	
3	3	5		6		3		6		6	
3	3	5		5		3		3		6	
3	3	3		3		3		4		6	
3	3	3		6		3		5		5	
3	3	5		6		3		5		5	
3	3	5		6		3		6		5	
3	6	3		6		6		6		5	
3	3	6		4		6		6		5	
3		5		6		6		6		3	
3		3		3		6		5		3	
3		5		6		3		5		5	
3		3		6		5		5			
3		5		5		3		5			
0		3		6		3		3			
3		5		5		3		3			
3		3		6		3		5			