AN INVESTIGATION INTO THE CLASSIFICATION ABILITIES OF SOUTH AFRICAN INDIAN CHILDREN

by

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CHAPTER ONE

1.1 INTRODUCTION

The development of classification ability is an important aspect of the cognitive development of the child. For example, Wei, Lavatelli and Jones (1971) say that studies on the development of classification in young children make it appear to be a very important intellectual operation. Inhelder and Piaget (1964) regard the ability to classify as basic to the development of logical thought processes.

Classification ability enables the child to organize stimuli from the environment into classes and sub-classes on the basis of resemblances and differences among them. Stimuli that share some common property or attribute are put into one class while those that do not possess the attribute are put into another class. In this way, the vast amount of environmental stimuli is reduced to a relatively small number of classes of increasing degrees of generality. This introduces orderliness and economy in the way in which the child conceptualizes the elements in the environment and thus facilitates learning.

According to Inhelder and Piaget (1964), true or hierarchical classification involves the ability to differentiate and progressively co-ordinate simultaneously two properties of stimuli, namely, the intension and extension of the class. Class intension refers to the defining property or criterion of the class. The child must first be able to identify and isolate the class intension. For example, given an array of stimuli which may include flowers, the child must first conceptualize that he can form a class of, for example, flowers. The class intension in this case would be the critical characteristic of being a flower. Having identified and isolated the class intension, the child must then be able to identify all the elements in the array that posses the attribute of being a flower. The list of all the items possessing the critical attribute is the class extension. The child must then place all the elements that possess the attribute of being a flower into one class. Any element that does not possess this attribute is precluded from the class of flowers and must be placed in another class. When the child can do this he has acquired true classification ability.

1.2 TYPES OF CLASSIFICATION

Two basic types of classification behaviour can be identified, namely, free classification and matrix, or multiplicative classification. There are fundamental differences between the two types in terms of the ways in which these abilities are elicited and manifested in the child's behavioural responses. Also, there are differences between the Genevan school exemplified by Piaget and the American school exemplified by Bruner in terms of assessment procedures, theoretical explanations and the kinds of predictions made from them. These differences are amplified in Chapter Two. For the present an attempt is made to distinguish briefly between free and matrix classification.

1.2.1 Free classification

In free classification tasks, the subject is presented with an array of stimuli and asked to sort them so that the things that are alike are put together. There is no directive from the experimenter as to the number or nature of the classes to be formed. The child is free to respond in any way he likes. Obviously, there can be no right or wrong answers. This is the basic procedure used by both Piaget (Inhelder and Piaget, 1964) and Bruner (1967).

As far as the interpretation of responses are concerned, there are differences in emphasis between the Genevan and American schools. Inhelder and Piaget (1964) seek primarily to offer an ontogenetic explanation of the responses. The responses reveal the stage at which the child is functioning (See Chapter Two) which is determined by the type of response and, which in turn provides a data on the level of the child's conceptual development.

Bruner (1967), on the other hand, places greater emphasis on the way the child processes the available information to arrive at a basis for classification and the consistency of the child's responses. Of interest are issues such as the attribute of the stimulus the child uses as a basis for sorting, how this changes from a perceptual to a conceptual basis, and a search for possible cultural factors that influence the responses.

1.2.2 Matrix classification

In matrix classification the child is required to recognize simultaneously two relevant attributes of the stimuli and also the way in which they are changing. This requirement is basic to the assessment procedures employed by Inhelder and Piaget (1964) and Bruner (1967). The child must recognize, for example, that a stimulus is a hat and also that it is green. In addition, he must be able to recognize how the stimulus is changing in successive cells in both the horizontal and vertical directions.

Inhelder and Piaget (1964), assess matrix classification ability by requiring the subject to complete a pattern successfully on the basis of "clues" provided. The matrix is usually formed by arranging stimuli in cells in such a way that a horizontal and vertical relationship among the stimuli is evident. One or more of the cells are left incomplete and the subject has to choose the stimuli that will complete the pattern.

The techniques employed by Bruner and Kenney (1967) in assessing matrix classification ability include replacement, reconstruction, and transposing cells. In these three techniques, the child is initially presented a completed matrix. In replacement, one or more of the stimuli are removed and the experimenter observes whether these are correctly replaced. In reconstruction, the entire matrix is dismantled and the child is required to reconstruct it. Transposing requires the child to change the positions of the stimuli while at the same time keeping the vertical and horizontal relationships.

No matter which technique is employed, matrix classification ability requires the simultaneous attending to two relevant attributes of the stimulus and also awareness of the ways in which the stimuli are changing in successive cells. Hence matrix classification is presumably a more difficult task than free classification which requires sorting according to similarity. Developmentally, matrix ability should emerge later than free classification ability.

1.3 IMPORTANCE OF CLASSIFICATION BEHAVIOUR

The importance of classification behaviour can be gauged from the implied emphasis of the contents of pre-school and primary education. The learning of basic concepts such as colours and shapes and the recognition of similarities and differences among them depend upon the ability to classify. Formal education is facilitated if the child can readily perceive similarities and differences among the things and issues that have to be learned.

A hierarchical or true classification results in the formation of classes of increasing degrees of generality and this reduces the volume of learning required for specific items. In a hierarchical tree (Bower, Clark, Winzenz and Lesgold, 1969) of this sort, information of the superordinate class is common to all the sub-classes below it, so a relatively few details with regard to these need be acquired. For example, if the superordinate class is mammals, it may be subdivided into the sub-classes of say, herbivorous and carnivorous mammals. If the specific list of animals to be studied included lion, tiger, cow and horse, a child who could not classify would learn a lot of details about each. Apart from the laborious nature of the task he would be unable to see similarities and differences among them. By arranging them into the two sub-classes of mammals, he has to learn the general characteristic of mammals, a few details of the sub-classes, and comparatively fewer details of the specific animals. In this way not only is economy and orderliness introduced, but the understanding of the similarities and differences is also developed.

The learning of mathematics also requires classification ability. Set theory is one example of the formal attempt to teach classification concepts. Without classification ability a child cannot understand the relationships between sets and subsets.

In general, almost all learning that requires the recognition of similarities and differences among stimuli is dependent on the acquisition of classification ability. Since classification ability is so important, it needs to be understood as fully as possible.

1.4 CURRENT STATUS OF RESEARCH

Much of the research into classification behaviour may be categorized either in terms of the type of classification ability investigated or its theoretical orientation. Piagetian (Inhelder and Piaget, 1964) research focuses on the ontogenetic changes that occur in the growing child as he develops from a stage of complete absence of classification ability until he reaches the stage of true classification. The emphasis is on qualitative changes in verbal and behavioural responses. Bruner's (1967) theories have generated research on how the child processess cognitive information as he advances from classifying on a perceptual basis to classifying on a conceptual basis (Cole and Scribner, 1974).

From the review of literature (See Chapter Three) the following research focuses have become identifiable:

1. Studies attempting to demonstrate and verify Piagetian formulations in different contexts. These have adopted the Piagetian models, e.g., Wei, Lavatelli and Jones (1971), Denney (1972).

2. Research following Bruner's works has focused attention on two main aspects of the subject's performance. The first aspect is whether the child uses a perceptual (colour, size, shape) or conceptual (what things can do,

or what people can do with things) basis. The second aspect is whether or not the child uses a single attribute consistently as the basis for grouping.

According to Cole and Scribner (1974), findings with respect to the above two aspects have provided the empirical foundations for theories of cognitive development that stress progression from a kind of thinking that is concrete and context-bound to thinking that is abstract and rule-governed.

3. Some research has focused on the effect of stimulus variables on classification behaviour. The emphasis has been on how performance varies on a given task when familiar and unfamiliar materials are employed, rather than on ontogenetic ability (Price-Williams, 1962; Irwin and McLaughlin, 1970; Okonji, 1971).

4. A small group of studies attempted to investigate the performance versus ability issue by researching re-classification ability. The emphasis has been on whether the child's initial choice of class intension is the only one he knows or whether he simply prefers this particular intension. The question these have attempted to answer is "Do children, or can children, find other criteria for classifying the same stimulus array?" (Gay and Cole, 1967; Schmidt and Nzimande, 1970).

5. Studies on matrix classification have employed various techniques such as replacement, reconstruction, transposition and completion. The emphasis has been on the child's ability to simultaneously attend to two attributes of the stimuli (Inhelder and Piaget, 1964; Bruner and Kenney, 1967; MacKay, Fraser and Ross, 1970).

6. The remaining research may be categorized "compromise" research. These have investigated a wide variety of issues adopting an eclectic approach.

The present investigation is, for the greater part, Piagetian in orientation. The assessment procedure is basically Piagetian for both free classification and matrix tasks. So, too, is the choice of the stimuli. Thereafter, the investigation follows an eclectic approach. Unlike the Piagetian clinical method, the results are analysed in terms of Bruner's approach. The examination of stimulus variables is also a departure from traditional Piagetian research. The comparison of free and matrix classification on the same subjects using the same stimuli is an extension of much previous work.

1.5 MOTIVATION

Classification ability is influenced by a wide variety of variables. Some of the variable relate to socio-cultural factors (Wei, Lavatelli and Jones, 1971), amount of schooling (Schmidt and Nzimande, 1970), the familiarity of the stimuli used (Price-Williams, 1962), the method of presentation of the stimuli (Denney, 1972a) and the age of subjects (Wei, Lavatelli and Jones, 1971).

Because of this, results have sometimes appeared contradictory and cross-cultural comparisons have been extremely difficult. Denney (1972) says that the lack of consistency in the findings is not too surprising, since each of the various studies have employed different procedures. In addition some of the studies raise methodological issues that need investigation (e.g., Wei *et al.*, 1971). For these reasons, further research on classification ability is needed.

The importance of classification ability to the conceptual development of the child has already been stated. Further research is required to understand more clearly how some of the variables associated with it actually affect its attainment.

Only then can a programme of intervention and change suggested by Bruner (1967) be implemented with confidence.

The relationship between free and matrix classification has not been examined among the same children using the same stimuli. Matrix classification is important as stimuli seldom occur without a matrix-type relationship to each other. Mathematics requires an understanding of matrix-type relationships. While matrix classification has been researched independently, no data is available as to its relationship with free classification. Which occurs earlier? What explanation may be offered? These questions need to be answered.

It has been demonstrated that familiar stimuli produce superior results to those obtained on unfamiliar stimuli on both free classification and matrix tasks (Price-Williams, 1962; Bruner and Kenney, 1967). But the familiar stimuli have been so specific to individual studies that meaningful comparisons have been ruled out. The basic criterion for familiarity seems to be three-dimensional real objects. How will performance be affected if the three-dimensional stimuli are also geometric forms equivalent to the popular two dimensional shapes such as triangles, circles and squares? These issues need investigation.

An additional motivation is the peculiar position of the Indian child in South Africa in comparison to children from the other cultures that have been studied. From the description of literacy levels and the extent of technological advancement of the so-called primitive tribes such as the Mano of Liberia (Irwin and McLaughlin, 1970) or the Ibusa (Okonji, 1971), it would appear that the South African Indian child is obviously more advanced. At the same time it would appear that these children are not as advanced as their counterparts in the more technologically advanced societies such as the children from the United States. This is inferred from factors such as the socio-economic and political conditions prevailing in South Africa and the scarcity and prohibitive costs of pre-school and nursery education. The target population would intuitively appear to lie in a stage of cultural evolution that may be regarded as intermediate between the primitive tribes on the one hand and the technologically advanced societies on the other. It is hoped that this population group would therefore provide some interesting basis for cross-cultural comparison of classification ability.

It would appear that much research has already been done on the development of classification ability. It is hoped that the present study will continue this tradition and provide some answers to old questions and raise new questions which would generate further research in the area.

1.6 AIMS OF THE INVESTIGATION

The general aim of the present investigation is to empirically determine the age changes in classification behaviour and to identify some of the variables affecting it. To this end some methodological refinements on previous studies will be made, details of which will be presented in Chapter Four.

Specifically, the following aims may be listed:

1. To examine the developmental changes in free classification and matrix classification ability among 9 year old and 12 year old Indian subjects.

2. To investigate differences, if any, in performance using two-dimensional and three-dimensional stimuli.

3. To investigate differences, if any, between free classification and matrix classification tasks.

4. To investigate the preference versus ability issue by examining reclassification behaviour in free classification tasks.

5. To examine differences, if any, between behavioural responses and appropriate verbal justifications of such responses.

6. To provide continuity and cross-cultural generality to the previous investigations in the area.

1.7 HYPOTHESES

In order to fulfil the aims listed above, the following hypotheses will be tested:

1. There will be significant age differences between the 12 year old subjects and the 9 year old subjects in their free classification responses on both two-dimensional (2-D) and three-dimensional (3-D) stimuli.

2. There will be significant age differences between the 9 year old and 12 year old subjects in their matrix classification responses on both 2-D and 3-D stimuli.

3. The responses of the subjects on the 2-D stimuli will be significantly different to their performance on the 3-D stimuli on both the free and matrix classification tasks.

4. On the free classification tasks, there will be significant age differences between the number of 12 year old and 9 year old subjects that successfully reclassify the 2-D and 3-D stimuli.

5. There will be a significant age difference in the number of complex multi-dimensional free classification responses given by the younger and older subjects on both 2-D and 3-D stimuli.

6. There will be a significant difference between the free classification and matrix classification responses of the subjects on both 2-D and 3-D stimuli.

7. There will be a significant difference between the younger and older subjects in the adequacy of their verbal explanations for their behavioural responses on both free and matrix classification tasks.

1.8 CONCLUSION

In this chapter, an attempt has been made to delineate the problem to be investigated and to formulate the aims and hypotheses of the present investigation. The theoretical framework, issues raised, relevant empirical research and the design of the investigation are further discussed in the subsequent chapters.

CHAPTER TWO

THEORETICAL PERSPECTIVES

2.1 INTRODUCTION

In Chapter One, some theoretical approaches to the study of classification have been briefly mentioned. In this chapter a more detailed account of the major theories will be presented.

Two major schools of thought have given impetus to research on cognitive development in general and on classification ability in particular. The first which may be collectively labelled the Genevan School, has been pioneered by Jean Piaget and his co-workers. The second has been spear-headed by Jerome Bruner and his associates in the United States. Both these will be discussed at length in this chapter. Much of the empirical research on classification may be regarded as being influenced by one or the other of these two schools. The remaining studies, which form a small group, are either eclectic or atheoretical.

In the sections that follow the theories of Piaget and Bruner will be given attention.

2.2 PIAGET'S THEORY

The Piagetian theory is essentially a developmental theory, emphasizing the description of particular behavioural changes that occur at the different ages and the etiological factors that determine these changes. According to Ginsberg and Opper (1969), Piaget emphasized the role of biological inheritance and development in cognitive functioning. The research methodology that serves as Piaget's primary technique involves comparison of performances of children of different ages (or the same child at different points in its development) on some task or series of tasks designed to reflect the type of classification behaviour being studied (Glick, 1974).

The major points of behavioural emphasis in Piaget's theory of classification behaviour are:

1. Whether the child classifies objects in accordance with certain fundamental properties of a class, and
2. The ages at which various kinds of classification responses are observed.

According to Inhelder and Piaget (1964), mature classification involves the conception of a collection of things, whether they are immediately present or imagined. The processes by, and the ages at which the child changes his behaviour from immature to mature classification form the central issues.

According to Inhelder and Piaget (1964), some kind of classification is implicit in a great many activities and judgements of young children. If a child names a chair, or sits down on it, the inference is that the child has classified the object as a chair. But this is regarded as a kind of pre-classification activity. It is an ongoing part of ongoing behaviour. The child might just as easily use the chair to stand on to reach a shelf. The particular characterization of the chair as an object to sit on or an object to stand on is dictated by the needs of the moment. The child does not simultaneously recognize the two uses as being characteristic of the same object. This comes later with the development of appropriate schema.

According to Ginsberg and Opper (1969), after 1940 Piaget adopted the revised clinical method in his studies on classification behaviour. His original clinical method was highly dependent on verbalizations. The examiner posed the questions in words, and the child was required to give the answers in the same way. The questions usually did not refer to things or events which were immediately present, and the problems did not always involve concrete objects which the child could manipulate or even see. This method was found to be problematic because the child might not understand everything said to him. Even if the child did understand, he could not adequately express in words the full extent of his knowledge.

In the revised clinical method, which is the basis for the ensuing discussion, the examiner's questions refer to concrete objects or events which the child has before him. An effort is made to let the child express his answers by manipulating the objects, rather than relying solely on the child to express himself through language. What the child does with the objects, and not what he says about them, constitutes the primary data. However, as Piaget usually investigated the child's understanding of abstract concepts that are not easily manifested by manipulating concrete materials, a certain amount of reliance still has to be placed on verbal responses. This necessitates asking questions and pursuing answers in a flexible and understanding way. Thus it can be seen that the revised clinical method has been an attempt to reduce the reliance placed on language.

The Piagetian concept of classification ability may be illustrated with an example. In terms of the revised clinical method, the child is expected to manipulate objects before him to demonstrate his ability. Assume the child is presented with a stimulus array consisting of geometric forms varying in shape (circles and triangles), colour (red and green), and size (small and large). The methodology employed is to instruct (request) the child to put together those things that are alike in some way.

The investigator then observes the behavioural responses of the child as the primary data. This usually involves noting the qualitative changes in behavioural responses among children of different ages. Children under five years of age will not manifest classification ability. Above this age, various kinds of classification behaviour may be observed. Some children may put all the triangles together and all the circles together, disregarding colour and size. Others may put all the red elements together and the green ones together disregarding shape and size. A third possibility is grouping on the basis of size, disregarding colour and shape. All of the above responses are based on similarity on one dimension only, ignoring the other salient dimensions of the stimuli. According to Inhelder and Piaget (1964), this marks the beginning of classification ability.

An advancement of the above is the behaviour which demonstrates the child's ability to simultaneously consider two properties of the stimuli. Classes may be formed consisting of green triangles, red triangles, green circles, and red circles. Other subjects may put together the large triangles, the large circles, the small triangles, and the small circles. Although two dimensions are being considered simultaneously in this type of responses, Inhelder and Piaget (1964) still do not regard this as true classification for one important reason. The child is still not considering all the relevant attributes of the stimuli at the same time.

The stage of true or hierarchical classification is reached when the child can simultaneously consider all three attributes of the stimuli. At this stage the child should be able to form a class of triangles with colours separated and the sizes seriated. He should be able to do the same to the circles. This type of behaviour reveals a complete understanding of the individual elements and their relationship to the total array.

It may be mentioned at this point that the true or hierarchical classification responses are evidenced in free classification tasks. In the structured matrix classification tasks, the child is only required to attend to two attributes of the stimuli at a time. Consequently matrix classification ability may be assumed to be midway between undimensional free classification and true or hierarchical classification ability.

The example discussed provides the basis for an in depth analysis of the specific developmental stages and substages in the acquisition of classification ability.

2.2.1 Stages in the development of classification ability

It has already been stated that the Piagetian theory is essentially a developmental theory, placing great emphasis on the description of particular changes that occur in classification behaviour at different ages. Before the age-stage issues are examined, it would be helpful to first consider what Piaget means by "properties of a class" (Inhelder and Piaget, 1964).

2.2.1.1 Some properties of a class

The following properties of a class have been summarized by Ginsberg and Opper (1969):

1. Classes are mutually exclusive or disjoint. No object is a member of more than one class simultaneously.

2. All members of a class share some similarity. If a class is formed consisting of all triangles, then all the other elements share the property of triangularity. Triangularity is the defining property, or intension of the class.

3. Each class may be defined in terms of a list of its members. Such a list is the extension of the class.

4. Intension defines extension. In other words, if the defining property of a class is known, the elements that belong to the class can be listed.

A child who classifies in accordance with the above properties is regarded as having reached the stage of mature classification. The way in which the child's responses change from a complete absence of classification ability to the stage of true or hierarchical classification is explained by way of developmental stages. The stage concept involves both a discussion of the ages at which the changes occur as well as the kinds of changes observed. Inhelder and Piaget (1964) stress that age norms are only approximate as some children pass from one stage to the next fairly quickly while others take longer. However, the sequence of development is invariant. A child must first manifest the characteristics of Stage 1 before he can advance to Stage 2.

2.2.1.2 Stage 1 : Graphic Collections (Ages 2 to 5 years)

According to Inhelder and Piaget (1964), the graphic collections stage covers the early part of the pre-operational stage of conceptual development. Children at this stage do not arrange elements into collections and sub-collections on the basis of similarity alone. They arrange elements into graphic collections which stand midway between a composite spatial pattern and a class. Inhelder and Piaget (1964) use the term "graphic collections" to refer to a spatial arrangement of the elements where the child is unable to distinguish between extensive and intensive properties. The child may place a triangle over a square because he thinks these two forms must somehow be related. While the child may recognize similarities and differences, these are always applied to successive pairs and remain unconnected to the whole array. They do not lead to the formation of a class which bears simultaneously on all the elements concerned. A similar type of response has been described as a "syncretic heap" by Vygotsky (1962).

Inhelder and Piaget (1964) distinguish five sub-stages within the stage of graphic collections.

1. Small Partial Alignments:
   The subject does not bother to classify all the objects in front of him and is content to make a number of independent arrangements using some of the material. The arrangements are always linear. Similarity is established between the first element chosen and the second, followed by a more or less independent relation between the second and the third, and so on. For example, the child may place the large red triangle next to the small red circle. He sees redness as the relationship between the first and second elements. He next places the small green triangle next to the large green triangle. Triangularity is now taken as the relationship, completely ignoring the initial relationship.

2. Continuous Alignment With Fluctuating Criteria:
   This type of response is characterized by the child making a long line of subsets of the elements. He forgets whatever went before as he moves from one element to the next, so that he changes the criterion for similarity in the successive comparisons. This is similar to the small partial alignments except for two things. Firstly, one continuous alignment is

made instead of several short ones, and secondly, all the stimuli are used. However, the child is unable to evolve a schema which is sufficiently differentiated to comprehend all the elements of a class simultaneously.

3. Reactions Between Alignments And Collective Or Complex Objects:
In this type of response the child starts by making an alignment but progresses to making complex objects. He may arrange two triangles to form a house.

4. Collective Objects:
This type of response is characterized by the child recognizing homogenous elements from the arrary but arranging them to form definite shapes. The child may arrange two triangles to form a square.

5. Complex Objects:
The subject interprets the instructions as no more than a request to construct something with the elements. He completely loses sight of the initial purpose of the classification task and proceeds to construct, for example, a house with the stimuli.

In summary, during Stage 1, children allow themselves to be guided by whatever they perceive in the stimuli. They are unable to co-ordinate intension and extension. Inhelder and Piaget (1964) suggest that cognitive structures needed for such coordination have not yet developed. The child therefore oscillates between intension and extension.

2.2.1.3 Stage II : Non-graphic Collections (5 to 7 years)

Inhelder and Piaget (1964) describe this stage as the stage of quasi-classification as distinct from the preceeding stage which amounts to no more than pre-classification behaviour. This stage occurs during the latter part of the pre-operational period.

During the stage of non-graphic collections, the child assigns objects to one or another class on the basis of similarity alone but the several collections are simply juxtaposed instead of being used as a basis for hierarchical class structure. Hence the use of the term "collection" rather than "class" to describe this stage (Inhelder and Piaget, 1964).

In the Graphic Collections stage described earlier, the child feels in no way compelled to use all the elements, nor does he see the need to form several classes. In other words, the child does not recognize that Class A includes all the elements having property "a" and that it includes only elements having property "a". Neither does he realize that all the elements must be classified, and that if there is only one element of a kind, it must constitute a separate class of one item.

During the non-graphic collections stage, the child understands all of the above. But he does not yet understand an important criterion for class inclusion, namely, the "all" and "some" conditions of class inclusion (Inhelder and Piaget, 1964). For example, the child will divide squares (B) and circles (B') into two boxes. He can next divide the squares into red ones (A) and blue ones (A'). He has thus reasoned that $A + A' = B$, and $A = B - A'$. But this reasoning prevails only as long as the sub-collections are united in the form $A + A'$. When these are dissociated either in space or thought, he no longer connects the subcollections with the whole collection. The child will deny that all the circles are blue because there are also blue squares. Inhelder and Piaget (1964) state that what the child reasons is that all A are B and not that all A are some of B. If the situation is manipulated so that the child is presented with a collection of items B (roses) divided into A (red) and A' (white) in such a way that $A > A'$ (more red roses than white roses), children at this stage report that there are more A than B (more red roses than roses).

The non-graphic collection is not a true classification. Its appearance points to the fact that the principles of similarity and differences tend, in time, to prevail over that of shape or belonging. But the collection is still bound by the condition of spatial proximity. Ginsberg and Opper (1969) state that the child focuses or "centres" on the collection he can see (red roses) and ignores the original collection (all the roses) which is no longer present in its initial state. This leads to faulty reasoning.

According to Inhelder and Piaget (1964), the transition from graphic to non-graphic collections is a gradual process and the emergence of Stage III is no more than a final term in a continuous development.

2.2.1.4 Stage III : True Classification (7 to 11 years)

Children in this stage, which coincides with the concrete operations stage, are capable of constructing hierarchical classifications and comprehending class inclusion. The child thinks simultaneously in terms of the whole and its parts and his thought has decentred from exclusive preoccupation with the whole or the part. The superordinate class (roses) is now seen as including all the subordinate classes (red and white roses). This implies the conservation of the whole (B), which now retains its identity although it is conceptually separated into its component parts (A and A').

Piaget (Inhelder and Piaget, 1964) reports that the child of this age can successfully classify and answer questions about objects that are present but often fails to give correct answers about objects that are not present. He concludes that the child's classification is concrete.

In summary, the child from 7 to 11 years has reached the most advanced stage as far as the classification of concrete objects is concerned. As hierarchical classification involves attending to all the relevant attributes of the stimuli, the child should by now also be able to successfully solve the matrix classification problems. Piaget proposes that these accomplishments can be described in terms of a logico-mathematical model (Ginsberg and Opper, 1969).

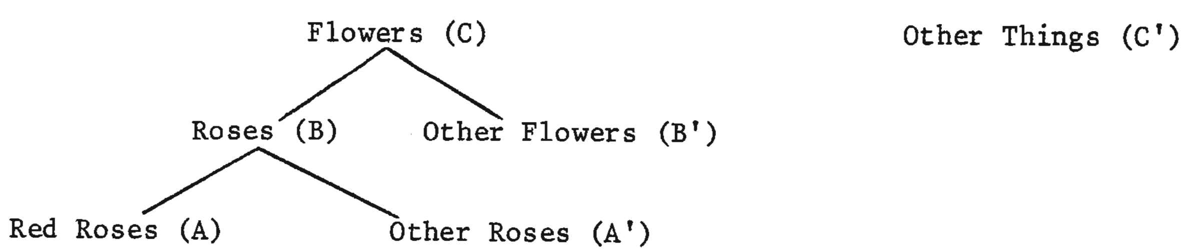
2.2.1.5 A logico-mathematical model of classification ability

Ginsberg and Opper (1969) state that Piaget feels that the ordinary language produces obscure and ambiguous psychological theorizing and must, therefore, be supplemented if not replaced by other modes of description. Being convinced that mathematics is an extremely powerful tool for communicating precise ideas, Piaget feels that it would be fruitful for psychologists to adopt a similar approach. The model discussed below is described in detail by Crize (1966) and is a formal description of hierarchical classification.

2.2.1.5.1 Grouping

The formal description called a Grouping begins with a classification hierarchy of the sort constructed by children from 7 to 11 years. This may be diagrammed as follows:

Fig. 1 Classification Hierarchy



The hierarchical tree is what is given and the grouping describes what the child can do with the hierarchy. In our previous description, Flowers (C) would be the superordinate class made up of Roses (B) and other Flowers (B'). Roses (B) would be the superordinate class made up of the subordinate classes Red Roses (A) and Other Roses (A'). In the logico-mathematical model, each of the classes (A, A', B, B', C and C') is an element of the system. There is one binary operator that may be applied to the elements, namely, combining. The operator is binary because it can be applied to only two elements at a time. From the above grouping, Ginsberg and Opper (1969) list five properties which describe the ways in which the operator may be applied to the elements.

The first property is composition, which states that if we combine any two elements of the system we will get another element of the system. For example A + A' = B. (Red roses + other roses = roses.)

The second property is associativity. If A, B and C have to be combined, it can only be done by taking two at a time. One way would be to state A + B = B. Then B + C = C, so that the final result is C. What has been stated is simply that red roses + roses = roses, and roses + flowers = flowers. Stated differently A, B, and C can be combined in various ways to give the end result C, for example, (A + B) + C = C, A + (B + C) = C, or (A + B) + C = A + (B + C). These equations express the fact that the child can combine classes in different orders and can realize that the results are equivalent.

The third property is identity which states that there is a special element in the system (the nothing element) which, when combined with any of the other elements, produces no change. For example, red roses + nothing = red roses (A + 0 = A). If red roses are not combined with any of the other elements we still have red roses (0 + A = A).

The fourth property is negation or inverse which is equivalent to taking away the same class, thus leaving the nothing element. For example, A - A = 0. The rule may be applied in the following way: If red roses are added to roses the result is roses (A + B = B). But if the other roses are taken away from roses, red roses are left (B - A' = A). This is regarded as one kind of reversibility. This type of reasoning enables the child to state that there are more roses than red roses, or that red roses are only some of the roses. This is a characteristic that distinguishes Stage III from Stage II described earlier.

The fifth property has the following aspects:

Firstly, if the class red roses is combined with itself, the result is still red roses (A + A = A). Piaget calls this tautology (Ginsberg and Opper, 1969). Secondly, if red roses are added to roses, the result is roses (A + B = B). Adding A to B is like adding nothing to B, the result B is unchanged. This is called resorption.

The logico-mathematical model is no more than an attempt to describe in formal, mathematical language, the processes underlying the child's classification. It does not in any way suggest that the child consciously uses such mathematical reasoning. Many adults, let alone children, have never heard of the special identity element for example.

It must also be remembered that Grouping which is a formal description of the construction of a classification hierarchy is not metrically quantitative (Ginsberg and Opper, 1969). It does not involve numbers but classes which may be of any size. Nor does it matter whether the child is classifying flowers, fish or aeroplanes. Rather, it is an attempt to capture the essence of the child's activities and to identify the processes underlying them. The Grouping is an abstraction which describes basic processes and potentialities of the child. It does not necessarily specify what a child does in any one task at any one time. Grouping explains and predicts behaviour and because it provides a description of structure, it goes beyond the details of any particular problem.

2.2.2 Developmental changes in classification behaviour

According to Flavell (1963), Piaget's theory of cognitive development is essentially an age-stage theory, in which four major developmental periods are described. These are the sensorimotor period (birth to 2 years), the preoperational period (2 to 7 years), the concrete operational period (7 to 11 years), and the formal operations period (11 years and above).

Of these, the preoperational and concrete operational periods are crucial in the attainment of classification ability as changes occur in the cognitive functioning of the child during these periods permitting the emergence of hierarchical classification behaviour.

There are certain features that characterise preoperational cognitive activity. One is centration, which is a tendency to focus on a limited amount of the information available. For example, in classification behaviour the child focuses on one attribute of the stimulus, perhaps colour, without taking into account other equally relevant attributes such as size or shape. He therefore cannot form a classification hierarchy. By contrast, the concrete operational child is characterized by decentration, a tendency to focus on several dimensions of a problem simultaneously and to relate these dimensions to each other. For example, in classification behaviour, the child recognizes that a stimulus is red, and that it is a triangle. At the same time he recognizes that there are non-red triangles and red non-triangles. Recognition of these relationships permit him to form a classification hierarchy.

Another feature of preoperational thought is that the preoperational child is static in the sense that the child centres on static states (Ginsberg and Opper, 1969). The child centres attention on the stimuli as they are before him and cannot visualize the transition to the final hierarchy. He is unable to visualize the array of stimuli transformed into classes and sub-classes. The concrete operational child on the other hand is attuned to change. His thinking is dynamic in the sense that he can form accurate images of the changes and what the final hierarchy would look like. Without this kind of dynamism, hierarchical classification is not possible.

The third characteristic of the preoperational child's thought is the lack of reversibility. The child is unable to reverse an operation and arrive at the original situation. He cannot, therefore, reason that transformations in shape or physical space does not change the length of two sticks. The concrete operational child's thought is characterized by reversibility. He can mentally reverse an operation and conclude that nothing has changed. As far as classification behaviour is concerned, the characteristic of reversibility is a requisite for hierarchical classification. It enables the child to deal with part-whole relationships and mentally visualize the superordinate class as being made up of sub-classes. Also, he recognizes that the sub-classes combine to form the superordinate class. This feature also gives him flexibility to form different hierarchical groupings.

According to Ginsberg and Opper (1969), Piaget conceives these three aspects, namely, centration-decentration, static-dynamic, and irreversibility-reversibility as interdependent. If the child centres on the static aspects of a situation, he is unlikely to appreciate transformations. If he can not represent transformations, he is unlikely to reverse his thought. By decentering he comes to be aware of the transformations, which thus lead to reversibility in his thought process.

The transition from the preoperational to the concrete operational stage is gradual and continuous. The child is not one day characterized by preoperational thought and the next day by concrete operational thought. Piaget (Ginsberg and Opper, 1969) explains the transition in terms of two general principles of functioning, namely, organization and adaptation.

Organization is the tendency to integrate cognitive structures into higher order systems or structures. Adaptation is the tendency to adapt to the environment. The processes of organization and adaptation are the product of a complex interaction between biological (inherited) and experiential (environmental) factors.

Piaget (Inhelder and Piaget, 1964) uses the term schema to refer to organized patterns of behaviour. Adaptation refers to the tendency to constantly reorganize old schema to cope with environmental realities. This is accomplished through two complementary processes, namely, assimilation and accommodation. Assimilation refers to the individual dealing with the environment in terms of his existing schema. The process of accommodation describes the individual's tendency to change schema in response to environmental demands. Schema that no longer serve a useful purpose must be modified, integrated, or discarded and replaced by new schema that work.

The above theoretical formulations may be illustrated with an example of a classification problem. The child is presented with a collection of red and black beads. The preoperational child, coping with the array in terms of centration, will classify the beads into the red ones and the black ones. The concrete operational child will realize that they form a general class of beads made up of sub-classes of red and black. This type of thinking involves decentration and reversibility. Dynamism will lead the child to conclude that beads belong to the general class of solid objects, an aspect not recognized by the younger child still engaged in static thought.

The rapidity with which the child advances from the preoperational to the concrete operational period is closely dependent upon the amount of stimulation the environment provides. If the environment makes no new demands on the cognitive capacities of the individual, accommodation will not take place. All that the environment can offer will be assimilated. If this *status quo* is disrupted, thereby demanding a new way of handling information, then accommodation and assimilation will again be initiated. This is the major reason why the role of the environment in cognitive functioning has been given so much emphasis in Piagetian theory (Inhelder and Piaget, 1964).

2.3 BRUNER'S THEORY

Bruner's theory emphasises the means by which the child organizes experiences for future use (Bruner, 1967). The child has certain information as part of his cognitive experiences. The way in which he uses and processes the information to arrive at a solution to a new problem is the point of major emphasis. The way in which cultural factors affect the processing of information and the ways in which intervention and change in cognitive functioning can be achieved form the basis of methodological and theoretical issues.

In Bruner's own words (Bruner, 1967) his studies in cognitive development have shown a change in emphasis. The emphasis has shifted from individual differences in cognitive operations to a study of intervention and change in cognitive functioning. He believes that there is a way of communicating ideas to children that is appropriate to a particular age and that it is futile educationally simply to wait passively for a child to grow into readiness. He also firmly emphasises the role of heuristics in cognitive development, that is, ways of proceeding that children pick up from the cultural environment. He states that growth comes as much from the outside in as from the inside out. Culture provides amplifiers in the form of technologies that enhance human cognitive capacities. Cognitive growth is therefore inconceivable without participation in a culture and its linguistic community.

According to Cole and Scribner (1974) Bruner's studies of classification centre on two aspects of the subject's performance, namely, the particular attribute the subject uses as the criterion for similarity and whether or not he uses a single attribute consistently as the basis for grouping. Conceptual development, therefore, involves a shift in the features of the world the child selects as a basis for defining how things are alike.

Very young American children tend to treat items as alike on the basis of perceptual qualities such as colour, size, shape, or position. With development, the child breaks away from this perceptual dominance and bases his classification on functional attributes. The main consideration becomes what things can do or what a person can do with things. The child also increasingly comes to group items together under a common class name (Cole and Scribner, 1974).

Much of the investigations that have provided the empirical foundations for Bruner's theories of cognitive development have been conducted by Bruner and his associates at the Centre for Cognitive Studies at Havard. Research into classification ability have provided information on patterns of growth that are displayed by different children. These patterns are explained in terms of grouping structures, which, while not directly analagous to the Piagetian age-stage concept, helps to describe characteristic patterns of responses of children at different ages.

2.3.1 Grouping structures

Olver and Hornby (1967) describe three major grouping structures that have been observed in classification behaviour. These are thematic grouping, which is evidenced till about age 6 years, complexive structure, which is the major tendency between ages 6 to 9, and superordinate grouping, which is evidenced mainly in the older children.

2.3.1.1 Thematic grouping (up to 6 years)

Thematic grouping involves putting things into a group without there being any identifiable feature that justifies their inclusion into one group. An attempt is made to tie up the items in a sentence which carries a story or thematic line. For example, the child may put apple, bread, and nail into one group and justify the grouping with the sentence "The boy was eating an apple while on his way to the shop to buy bread and nails."

2.3.1.2 Complexive structures

Olver and Hornby (1967) describe five manouvres for forming complexive structures. All share the common characteristic of using specific rather than universal rules for grouping. These are discussed in order of increasing cognitive ability.

1. Collections:
   The collection consists of finding complementary or somehow contrasting properties that things have. No similarity among items in a group is evident. For example a bell, a telephone and a radio may be grouped together because bell is black, telephone is blue and radio is red (contrast).

2. Edge matching:
   A chain of items is formed with similarity established between successive pairs. This is similar to Piaget's continuous alignment. For example, banana, peach and potato may be grouped together because banana and peach are yellow, and peach and potato are round.

3. Key rings:
   This type of grouping consists of taking one item and linking others to it by choosing attributes that share some similarity between the central item and each of the others. For example banana, peach, potato, milk, and air may be grouped together because all have germs.

4. Associations:
   The child links two items and then uses the bond between these items as a nucleus for the addition of other items. For example, a bell and a horn make music. Radio also provides music so it is grouped in the same category. If you fold a newspaper it crackles and makes a noise so it, too, is grouped with the rest.

5. Multiple groupings:
   This consists of forming several sub-groups without attempting to bridge the gap between them. For example, a banana and peach may be grouped together because they are yellow. A potato and meat go together because they are food. But no link is seen between the two classes, that is, both can be eaten.

2.3.1.3 Superordinate grouping (after 9 years)

This type of grouping is constructed on the basis of a common feature or features characterizing the items included in a group or class. From the number of common characteristics present in any stimulus array, the child selects one or a combination of a few to serve as the criterion for their inclusion in a class. For example, banana, peach and potato can be placed in a superordinate group because they all have skins, or they are all food. The general superordinate construction consists of stating a common characteristic of the items included in a group. Itemization may be added to superordinate grouping by explicitly stating how each item qualifies for class inclusion.

Broadly speaking, the superordinate grouping may be regarded as similar to Piaget's true or hierarchical classification. There is, however, a major difference. Piaget regards the stage of true classification as being attained only when the child simultaneously recognizes all the attributes of a stimulus and their relationship to the whole array. A child at this stage would therefore manifest matrix classification ability. The superordinate grouping on the other hand, can be based on the recognition of only one relevant attribute, (in the example given above, banana, peach and potato form a superordinate class because they all have skins). Such a system of grouping does not provide a sufficient condition for matrix classification. Bruner (1967) says that for matrix classification the child must recognize, for example, that a stimulus is a hat and that it is green. He must also be able to recognize how the stimulus is changing in successive cells in both horizontal and vertical directions. Obviously, in terms of the superordinate grouping, only those children who use a combination of characteristic as the criterion for class inclusion will manifest matrix classification ability. It may therefore be inferred that matrix classification ability emerges later than, or perhaps together with, superordinate groupings.

Using the above grouping structures as a basis for observing patterns of growth, Bruner (1967) makes the following observations.

At around age 6 years, changes begin to occur in the intellectual life of a western child. This involves a shift from a technique of dealing with things, one aspect at a time in terms of their perceptual appearance, to dealing with a set of invariant features several at a time and in some structured relationship.

Olver and Hornsby (1967) state that thematic grouping drops sharply around age 6 years. At age 6, half of the groupings made by children are thematic and half superordinate. (This indicates a superiority of western children over Genevan children who begin to show true classification ability between ages 7 to 11 years.) By age 9, the balance shifts to three quarters superordinate. By age 19 years the complexive grouping virtually disappears. When younger children use complexive grouping, they tend to use collections and edge matchings. The older children who use complexive groupings tend to use associations or key rings.

The same patterns of growth emerge whether words or pictures are used as stimuli and whether the child is given the items in a fixed order or allowed to choose his own groups. From age 6, linguistic structures increasingly guide what and how things will be alike (Olver and Hornsby, 1967). With the development of symbolic representation, the child is freed from dependence on moment-to-moment variation in perceptual vividness and is able to keep the basis for equivalence invariant.

2.4 COMPARISON OF THE TWO THEORIES

According to Glick (1974) the Piagetian theory is essentially a developmental theory, emphasizing the description of particular behavioural changes that occur at the different ages and the factors that determine these changes. Bruner's theory on the other hand, emphasizes the way in which cultural factors affect the processing of information and the ways in which intervention and change in cognitive functioning can be achieved.

The Piagetian methodology involves presenting children of different ages with an array of stimuli and observing how they put these together into groups and subgroups. Bruner's methodology follows a similar basic format with certain differences. Part of the methodology involves a search for stimuli appropriate for a particular child and a technique of presentation that will maximize the possibility of yielding successful responses.

As far as explanations of the responses are concerned, Piaget offers an ontogenetic explanation in terms of development of schema through assimilation and accommodation until the stage of concrete operations is reached. Bruner (1977) on the other hand, explains the responses in terms of how the child processes information and how the growing child comes to represent his experiences of the world. The role of language in facilitating the thought processes is also important.

Although the work of Piaget has provided a powerful stimulus to cross-cultural research (Glick, 1974), the exploration of free classification ability in different cultures has been along lines of ontogenetic changes. The emphasis has been on biological development, particularly those aspects that tend to be sensitive to environmental influences. This includes demonstrating and verifying Piagetian formulations in different contexts (e.g., Wei, Lavatelli and Jones, 1971; Denney, 1972).

Bruner's theory has generated hypotheses with respect to such aspects as classification-reclassification, generalizability of classification responses, and the effect of stimulus materials on classification ability. Questions have been posed with respect to such aspects as: are there performance differences between the use of pictures and actual objects as stimuli? Are there differences between familiar and unfamiliar stimuli? What effect do factors such as schooling and language have? These issues have been researched and have provided impetus for further research.

Besides the Piagetian studies and Bruner's studies, are the eclectic studies. These have adopted a mixture of both approaches both in terms of methodology as well as the preference for a particular interpretation of the research findings.

2.5 SUMMARY

In the foregoing discussion an attempt has been made to present the main aspects of the theories of Piaget and Bruner. In doing so, attention was given to their methodologies, the kinds of predictions made and the explanations of the behavioural responses. The eclectic approach which adopts parts of both theories has also been placed in its perspective. In the next chapter on the review of literature a detailed account of the various investigations will be presented.

CHAPTER THREE

REVIEW OF LITERATURE

3.1 INTRODUCTION

The literature on classification ability is vast and to present a review necessitates some arbitrary form of categorization. The most logical basis for categorization, and the one adopted in this chapter, is in terms of the aims of the present investigation (See Chapter One).

The review of literature is presented under the following broad categories:

(a) Studies which have investigated developmental changes in classification behaviour. These studies have been generated mainly by Piagetian formulations and the emphasis has been on investigating qualitative changes in the classification behaviour of children at different ages.

(b) Studies which have investigated the effects of variations in the stimulus materials on classification behaviour. The emphasis has been on how different types of stimuli affect the classification behaviour of children.

(c) Studies which have investigated the preference versus ability issue by examining reclassification behaviour. The emphasis has been on whether children can classify an array of stimuli in different ways. When requested to classify the stimuli just once, children choose varying attributes of the stimuli as the basis for their response.

The question arises as to whether their initial response is the only one they can make or whether they can classify in other ways, which would suggest that the initial response was simply one of preference.

(d) Studies which have investigated matrix or multiplicative classification. The emphasis has been on examining how success on the matrix tasks are affected by the age, stimulus, and method of presentation variables.

The above categories are not mutually exclusive. The same study, for example, may have investigated the age and stimulus variables. Or, one study could have investigated free and matrix classification ability. Nor are the above categories exhaustive of the literature on classification ability. Aspects of investigations falling outside the scope of the present investigation have been omitted. The categories listed above should be seen as no more than a convenient way of presenting the review in terms of the issues and problems raised in the present investigation.

The general plan of presentation of the review will be first to discuss some of the investigations and then to present a tabulated summary of the studies. As some of the studies have investigated more than one of the issues mentioned above, these will recur in the following sections.

3.2 DEVELOPMENTAL CHANGES IN CLASSIFICATION BEHAVIOUR

Piaget's theory of cognitive development (Inhelder, 1962; Inhelder and Piaget, 1964) makes a fundamental assumption that there is a fixed order in which concepts are acquired. This order is determined by the child's increasing ability to use complex logical operations. The assumption applies to the development of classification ability also, as this is one component of conceptual development.

Piaget's age-stage formulations have been the focus of attention of several investigations. Studies have explored both free and matrix classification. As matrix classification will be discussed as a separate section, the studies reviewed in this section concern basically free classification procedures.

Age changes in free classification ability have been reported by various researchers (Kofsky, 1966; Wei, Lavatelli and Jones, 1971; Denney, 1972(a): 1972(b)). The general conclusion is that as age increases, so does the complexity of the child's response. Kofsky (1966) states this in another way, saying that as the logical complexity of the task increases, the average age at which the task is mastered rises. These findings have been reported by earlier investigators (e.g., Vygotsky, 1962; Bruner and Olver, 1963). However, the conclusion is not as clear-cut as it would appear. There are more unknowns in the equation to predict mastery on a given task than just age. A detailed examination of some of the studies will clarify this contention.

Kofsky (1966) investigated classification responses as a function of age. The subjects were 122 children of ages 4, 5, 6, 7, 8 and 9 years. Each age group was made up of 10 boys and 10 girls, except the 4 and 7 year olds, each of which had one additional child. The level of intellectual functioning was controlled by including only children who were above average in intelligence. The stimulus material consisted of geometric blocks varying in shape and colour. (The free classification tasks were part of an array of eleven tasks which assessed a variety of abilities including conservation.) On the free classification tasks the subjects were required to group the stimuli on the basis of some recognizable attribute of the stimuli. The responses were quantified by awarding a score for each task the subject completed successfully. The data were subjected to an analysis of variance which yielded a significant age effect ($F[5,116] = 17,2 < 0,01$) in performance. Tukey's test indicated that 9 year olds performed better than 7 and 8 year olds, who, in turn, did better than the younger subjects. When the criterion for success was sorting on the basis of similarity alone, that is, recognition of any one stimulus attribute, 43% of the 4 year olds, 75% of the 5 year olds, 80% of the 6 year olds and 90% of the 7, 8, and 9 year olds succeeded. When the criterion for success was hierarchical classification, only 40% of 9 year olds succeeded. These results indicate that mastery at a task does increase with age and that the more complex the task, the higher the age of mastery.

Wei, Lavatelli, and Jones (1971) studied differences in classificatory skills in children of middle-class (MC) and culturally deprived (CD) environments at the kindergarten and second-grade levels. The sample consisted of 80 children, made up of 20 MC and 20 CD children of each age group. While both boys and girls were included, the exact number of each sex in the sample is not known. The mean ages of the children were 5 years 3 months for the kindergarten group and 7 years 6 months for the second-grade group. The stimuli for the free classification task consisted of miniature toy objects which could be grouped into four classes, namely, people, animals, houses, and eating utensils. Each child was presented with four sheets of paper and told to put on each sheet "whatever goes together" and to give reasons for his response. The results were quantified by awarding points for each correct responses and for each "appropriate" justification. The breakdown of the responses into the three Piagetian stages of development is tabled below.

TABLE 1 : COMPARISON OF GROUPS BY THE STAGE OF DEVELOPMENT

AGE AND GROUP	PERCENTAGE OF SUBJECTS AT EACH STAGE		
	STAGE I	STAGE II	STAGE III
Kindergarten : CD	85	10	-
MC	25	75	-
Second Grade : CD	-	70	30
MC	-	35	65

The results on Table 1 clearly demonstrate an age shift in classification responses. No child from the younger group had reached Stage III while no child from the older group was still in Stage I. This would seem to suggest that chronological age determines success in classification tasks. However, the results suggest that age alone is not the only factor determining success. There is an apparent interaction between age and environmental background. At each age level the effect of environmental background on the child's advancement from one stage to the next is quite dramatic. Among the younger children, 85% of the CD group were still in Stage I while 75% of the MC group had advanced to Stage II. While Piaget (1964) regards both these stages as being pre-operational, Stage II is an advancement on Stage I. Among the older children, 75% of the CD group were still in Stage II while 65% of the MC children had advanced to Stage III. In other words, 75% of the CD group were still functioning at the preoperational level whereas 65% of the MC group had advanced to the concrete operational stage. This finding casts doubt on the role of chronological age as the chief variable in predicting success on classification skills. Environmental background does seem to have a modifying effect on age *per se*. An analysis of variance showed the MC children progressed better on the free classification task than did the CD children ($F[1,76] = 19{,}62$, $p < 0{,}001$).

An examination of the percentage of children who succeed in correctly forming four classes revealed the following:

Kindergarten CD (5%), MC (45%), second grade CD (70%), MC (80%). Again the results indicate that the performance of second graders is superior to that of kindergarten children. For a mean age gain of 2 years 3 months, performance improved by 35% (from 45% to 80%) among MC children and 65% (from 5% to 70%) in CD children. The interaction between age and environmental influences is again highlighted. It would appear that among MC group, age has comparatively less effect on improvement between ages 5 to 7 (35% improvement), whilst among the CD group age has a greater effect (65%). This would indicate that both age and environmental background are important factors to consider when examining free classification ability.

The study reviewed above raises certain questions. Firstly, Wei, Lavatelli and Jones (1971) did not control the IQ of the subjects, so the effect this factor has on free classification ability is not known. Secondly, the procedure adopted may be questioned. By providing four sheets on which the child was asked to make his responses, the number of classes to be formed were implied. This possibly contributed to a greater measure of success than would have been the case if the number of classes to be formed had not been implied. The third question refers to the scoring of the responses. It would appear from the discussion that the data subjected to the analysis of variance included both behavioural and verbal responses. Each subject was awarded a total score on the basis of a correct behavioural response and an appropriate verbal justification. It would seem more appropriate to separate the two types of responses in the analysis, particularly, as Bruner (1967) has pointed out, classification ability can be manifested behaviourally without the presence of the verbal ability to justify the response.

Another study aimed towards demonstrating developmental changes in classification ability was conducted by Denney (1972a). The subjects were eight males and eight females from each of the age groups 2, 4, 6, 8, 12 and 16 years. The stimuli consisted of 38 wooden blocks varying in colour and shape. The main aim of the study was to investigate whether different experimental procedures affected the results. Two procedures were used. The traditional Piagetian procedure (Inhelder and Piaget, 1964) of asking the child "to put the things that go together", which Denney (1972a) refers to as the free grouping procedure, was compared with the Vygotsky (1962) procedure of using verbal labels. In the latter technique one of the stimuli is given a verbal label, usually a nonsense syllable, say, WUG, and the child is asked to pick out all the WUGS.

A 2 x 4 (procedure x type of response) chi square revealed that a larger variety of responses was obtained with the free grouping procedure (X^2 (3) = 67,86, $p < 0,001$). The two procedures do not appear to be comparable, hence conflicting results have been reported by Vygotsky (1962) and Inhelder and Piaget (1964).

As far as the developmental changes in free classification responses are concerned, the following results were reported by Denney (1972a) on the free grouping procedure:

The overall age x type of response chi square was significant (X^2 (15) = 62,08, $p < 0{,}001$). This resulted from three basic changes in frequency of certain type of responses with age.

(a) A significant decrease in the use of both no similarity responses (X^2 (5) = 32,25, $p < 0{,}001$), and building with similarity responses (X^2 (5) = 13,99 $p < 0{,}05$).

(b) A significant increase in the use of "form".

(c) A significant nonmonotomic trend (increasing up to age 6 and then decreasing) in the use of colour (X^2 (5) = 15,17 $p < 0{,}01$)

Two important aspects of the results reported by Denney (1972a) need discussion. Firstly, the qualitative changes in free classification responses as age increases are consistent with results reported by others (e.g., Kofsky, 1966; Bruner and Olver, 1963; Annett, 1959) and also consistent with the theories of Piaget (Inhelder and Piaget, 1964) and Bruner (1967). The second aspect is one that has not been much discussed, namely that the experimental procedure significnatly affects the responses of children. The importance of this conclusion lies in the fact that it would be futile to compare classification ability cross-culturally unless the experimental procedure is standardized. This is the approach implied in Bruner's (1967) formulations.

Denney's (1972a) study raises certain further questions. Firstly, neither IQ nor environmental factors were systematically investigated, so their contributions to the overall results remain unknown. Secondly, the choice of stimuli needs mention. The stimuli were such that no matter which attribute (form or colour) the child chose, he would end up with classes of unequal sizes. What effect this would have on free classification behaviour is not known.

Another study by Denney (1972b) investigated classification behaviour among children aged 2, 3 and 4 years. There were 36 children in each age group with approximately equal numbers of boys and girls. All the children came from a middle class (American) background. The stimuli consisted of 32 cardboard figures varying in shape (square, triangle, circle and half circle), colour (red, blue, orange and green) and size (large and small). The instruction given to the subjects were typically Piagetian.

For the purposes of comparing the responses to those obtained by Piaget (1964), the responses were categorized pregraphic, graphic, and non-graphic collections and true classification. Denney (1972b) reports that her findings do not support Inhelder and Piaget's (1964) proposal that graphic and non-graphic collections are two distinct stages that precede the development of true classification.

Of greater relevance to the present investigation are the findings concerning age changes in responses. Denney (1972b) divided the responses into 3 categories, namely, no similarity, incomplete similarity, and complete similarity. The results are tabled below.

TABLE 2 : FREQUENCY OF RESPONSES IN THE NO SIMILARITY, INCOMPLETE SIMILARITY, AND COMPLETE SIMILARITY CATEGORIES

CATEGORY	AGE IN YEARS		
	2	3	4
No similarity	18	4	4
Incomplete similarity	16	19	9
Complete similarity	2	13	23

The above data yielded a significant relationship between age and type of response (X^2 (4) = 36,09, p < 0,01). The overall significant relationship was attributed to the following:

(a) A significant decrease in no similarity responses as age increased (X^2 (2) = 15,08, p < 0,001).

(b) A significant nonmonotonic relationship (increasing from age 2 to age 3 and decreasing from age 3 to age 4) between age and incomplete similarity responses (X^2 (2) = 6,37, p < 0,001).

(c) A significant nonmonotonic trend (increasing up to age 6 and then decreasing) in the use of colour (X^2 (5) = 15,7, p < 0,01).

Somewhat surprising was the finding that there was no relationship between age and the number of dimensions employed (X^2 (2) = 0,83, p > 0,05). In the terminology of the present investigation, there was no age difference in the number of complex multidimensional responses and simple undimensional responses given by the children. Equally surprising was the finding that of the 23 responses, 48% (11 out of 23) were multidimensional responses. In terms of Piaget's (1964) theory, the ability to give multidimensional responses only appears between the ages 7 to 11 years. These results seem to suggest that American children are learning to respond to similarities and differences at a much earlier age than Genevan children.

Mallet and Drew (1974) investigated the effects of age and socio-economic status (SES) on free classification ability using Bruner's (1967) methods. Subjects were presented an array of objects to be grouped.

The testing procedure was standardized and the responses were scored as conceptual when the grouping was exhaustive and conceptually justified, transitional conceptual when the grouping was exhaustive and was verbally justified with both an abstract and a concrete rule, and non verbal conceptual when the grouping was exhaustive but not justified.

The results obtained seem to suggest that third-grade children of both middle and lower SES classify more on concrete basis than do the sixth-grade children. Also, significant SES x age interactions on both the number of conceptual responses ($F(4,62) = 10,14$, $p < 0,001$) and the non-conceptual responses were observed ($F\ 4,62) = 53,4$, $p < 0,001$). This finding is consistent with those reported by Wei, Lavatelli and Jones (1971).

In summary, the studies reviewed indicate that there is significant improvement in free classification ability as age increases. Age then is a good predictor of free classification ability. But caution has to be exercised when generalizing, since the experimental procedure employed (Denney 1972a), and the socio-economic environmental influences (Wei, Lavatelli and Jones, 1971; Mallet and Drew, 1974) also influence the results.

3.3 INFLUENCE OF STIMULUS MATERIAL ON CLASSIFICATION BEHAVIOUR

Several investigators have focussed attention on the effect the stimulus material has on free classification responses. While the basic idea has been to compare performances on familiar and unfamiliar stimuli, the concept of familiarity has varied from researcher to researcher making generalizations from one group of subjects to another virtually impossible. In general, the findings seem to suggest that the choice of stimuli does have a significant effect on facilitating free classification responses (Price-Williams, 1962; Irwin and McLaughlin, 1970; Deregowski and Serpell, 1971; Okonji, 1971).

Price-Williams (1962) investigated the familiarity issue among educated and non-educated Tiv children of Nigeria ranging in age between 6½ years to 11 years. The stimuli consisted of 10 kinds of plants and 10 kinds of animals, all of which were familiar to the Tiv children. The experimental procedure and the interpretation of results were basically those of Piaget (Inhelder and Piaget, 1964). The child was asked to group the objects into rows so that the objects in each row belonged together. The child was requested to continue grouping in different ways until he declared that he could find no further way of doing so.

The results showed that even the youngest children ($6\frac{1}{2}$ year old) successfully classified the objects. All the children also re-classified the objects. The younger children found between three and four different ways of doing so while the older 11 year old children found about six different ways. The animal stimuli were generally classified in terms of name of the creature, colour, size, number of legs, domesticity versus wildness, and edibility. The first choices seemed to be predominantly in terms of name of the creature among both the literate and illiterate groups. Also, while no literate child used domesticity versus wildness as the basis for sorting 13% of the age equivalent of class IV and the same percentage of the age equivalent of class V illiterate subjects sorted on this basis.

The plant stimuli were sorted mainly on the basis of edibility by both groups of subjects at all four age levels.

The results do suggest that successful classification responses can be elicited if the appropriate stimulus domain is utilised. Furthermore, both the literate and illiterate children sort the plant stimuli on the basis of the abstract property of edibility. Whild these results are interesting and informative in their own right, they provide little basis for cross-cultural comparison. All that can be said is that the familiar stimuli produce a high rate of success. But the stimuli used were far too specific to the Tiv culture for the results to be generalized to other cultures. Also, since the traditional Piagetian-type stimuli were not used, one cannot really state convincingly how these children would have performed with less familiar materials.

Irwin and McLaughlin (1970), in their study of classification ability among the Mano of Liberia contrasted classification abilities as applied to two-dimensional representations of geometric figures which varied in number, colour and shape, (unfamiliar stimuli) and bowls of rice (familiar stimuli) which varied in size of bowl, type of rice and cleanliness (polish) of rice.

It was found that the school children were better than the adults in classifying the less familiar two-dimensional geometric stimuli. However, the adults were as good at classifying the bowls of rice as the children were at classifying the geometric stimuli. The contrast between these two types of stimuli involved more than just the difference between familiar and unfamiliar stimuli. It also involved mode of representation, as two-dimensional cards and three-dimensional real objects were used. Which of the factors actually contributed to the results, the familiarity of the stimuli or the presentation mode, is not clear. This confounding could have been eliminated if the 2-D stimuli were pictures of the bowls of rice rather than geometric shapes. Alternatively, the geometric shapes could have been presented as 3-D real objects such as prisms, cubes and spheres. In either case the evidence for familiarity would have been much stronger. Evidence in support of superior results on familiar stimuli has been provided by Okonji (1971). Deregowski and Serpell (1971) provided less confounded data on the mode of presentation.

Okonji's (1970) investigation conducted among the Ibusa and Scottish subjects demonstrated that at older age levels the Ibusa showed superiority over the Scottish subjects when the stimuli were familiar to the Ibusa but not to the Scottish. When equally familiar materials were used, no differences were observed.

The study of Deregowski and Serpell (1971) was conducted among Zambian and Scottish school children. The stimuli consisted of a set of 8 toy objects, a set of colour photographs of these toys and a set of black and white photographs of the same toys.

Hence the stimuli were essentially from the same domain, that is, toys, unlike those used by Irwin and McLaughlin (1970). What differed was the mode of presentation. One set of stimuli presented the actual objects whilst the other two sets were pictorial representations.

The result of the study revealed that the Scottish children showed a marked superiority over the Zambian children in classifying the photographs. There was no difference between the two groups when it came to classifying the actual objects. These results indicate that pictures and the actual objects they represent are not of equivalent difficulty to Scottish and Zambian children.

In general the results of studies concerning the effect of familiarity of stimuli on classification ability seem to suggest that familiar materials allow for the use of more advanced mental operations. However, Glick (1974) points out that there is some doubt about this assumption. As evidence, the investigation by Greenfield (1972) is cited. In this study, the Mexican subjects, particularly the younger ones, seemed resistant to break up functionally adequate sorts, based upon habitually applied principles, in order to fulfil the experimenter's wishes. The cut flowers that they were asked to classify were stimuli that they worked with normally and were accustomed to sort them in a particular way. The experimental situation required them to now do this differently. This they seemed reluctant to do.

It would seem that two main considerations determine the choice of stimuli by researchers, namely, whether the materials are familiar or unfamiliar and whether actual objects or two-dimensional representations of the objects are used. It would appear that the more technologically advanced societies like the Scottish perform equally well with both actual objects and two-dimensional representations. The technologically less advanced societies like the Zambians do better on actual objects than on two-dimensional representations. When actual objects are used, the more familiar the objects the better the response. In the present investigation attempts will be made to ensure that the actual three-dimensional objects and the two-dimensional stimuli come from the same stimulus domain. At the same time the stimuli ought not to be too familiar to arouse the kind of resistance experienced by Greenfield (1972).

3.4 RECLASSIFICATION STUDIES

Inhelder and Piaget (1964) state that the stage of true classification is reached when the child understands the relationships between sub-classes in a hierarchical classification. Consequently, the true classifier should have no difficulty in reclassifying an array of stimuli in other ways than the one first chosen.

Bruner (1967), regards the stimulus attribute the child uses as a basis for classification as one of the key issues. Much has been said about the concreteness and abstractness of children's thinking in different cultures (Gay and Cole, 1967; Cole, Gay, and Glick, 1968) on the basis of identifying the stimulus attribute used in classifying objects.

A question that has often been overlooked in the studies mentioned is whether children use a particular attribute because they recognize no other, or simply because they prefer the one used. In other words, the question of preference versus ability needs to be investigated. This has been done by investigating reclassification behaviour.

Kofsky (1966) reported the following percentages of children that successfully reclassified the stimuli:

AGE (YEARS)	4	5	6	7	8	9
%	10	25	20	66	70	90

It can be seen that even the youngest children (4 years) were reclassifying to some extent (10%). By age 7, 66% of the children were reclassifying and this improved to 90% by age nine. Below age 7, the percentage of children reclassifying is low. If ability to reclassify is taken as a criterion for true classification ability, Piaget's (1964) contention that this stage is reached between the ages of 7 to 11 years is substantiated.

Price-Williams (1962) demonstrated that even the primitive Tiv children of Nigeria can reclassify. By awarding one point for each "shift", i.e., for each successful alternative way of reclassifying, he obtained the following data:

TABLE 3 : AVERAGE NUMBER OF SHIFTS PER AGE GROUP RECORDED BY LITERATE AND ILLITERATE TIV (NIGERIAN) CHILDREN

MEAN AGE (Years)	LITERATE	ILLITERATE
6,5	3,0	3,2
8,0	3,5	3,6
9,5	4,8	5,0
11,0	6,1	5,8

The results indicate that even the youngest group (6½ years) successfully reclassified the stimuli in at least 3 different ways. Also, there is a consistent progression with age in the average number of shifts attained by both the literate and illiterate children. The absence of any differences between the literate and illiterate groups, age for age, in the average number of shifts recorded suggest that in this specific context, chronological age was the more important determinant of re-classification ability than was the level of schooling.

The ability to reclassify has also been demonstrated among Zulu children and adults (Schmidt and Nzimande, 1970). Their sample consisted of children with and without western-type schooling, illiterate farm workers and urban workers. They report that 60% of the illiterate Zulu farm workers made a successful second sorting and very few could complete third sortings. The illiterate urban workers showed 70% success on second sorting. These results are similar to those obtained by Gay and Cole (1967) among Kpelle adults, about two-thirds of who could make a second sorting. The difference of 10% in favour of illiterate Zulu urban workers suggests that the urban environment does somehow provide amplifiers to empower human cognitive capacities. Since the farm-workers were by the nature of their work and home environment, less exposed to urban technological development, they showed poorer ability on reclassification. However, technology appears to interact with schooling as Schmidt and Nzimande (1970) report that the literate urban workers showed 81% success on second sorting, an advantage of 11% on their illiterate counterparts. The results suggest that among adult Zulus, it is not only the level of literacy that affects classification ability but, at least as far as the illiterate are concerned, whether they come from rural or urban backgrounds. The question that may be asked is, "Is it really the formal school experience or merely the exposure to the technologically advanced urban experience that facilitates classification ability?" The Piagetian age-stage formulation is clearly inadequate to explain the results. Bruner's (1967) "amplifiers in the form of technologies" explanation seems more relevant. However, the relative role of formal schooling and cultural technological advancement remains confounded.

As far as the reclassification ability of the children were concerned, Schmidt and Nzimande (1970) report that at each age level, the percentage of school children who made three successful sorts was higher than the percentage attained by children without schooling. The data are tabled below:

TABLE 4 : PERCENTAGE OF ZULU CHILDREN OF DIFFERENT AGES MAKING THREE SUCCESSFUL SORTS ON THE RECLASSIFICATION TASK

SUBJECTS	AGE LEVELS (YEARS)			
	4-6	7-8	9-10	13-14
Rural with schooling	1	8	16	27
Rural without schooling	3	4	4	7

From the data above, it can be seen that children with schooling showed a steady improvement with age, whilst children without schooling showed little improvement. Since the stimuli used in this investigation were different from those used by Price-Williams (1962), among the Tiv children, the results cannot really be compared. Nor can the results be compared to those of Kofsky (1966) although the stimulus domain (geometric shapes of different colours) were similar. Schmidt and Nzimande used both geometric shape cut-outs and picture representations of these shapes. All that can be said is that schooling did positively affect re-classification ability. What specific features of the schooling experience is responsible needs to be investigated.

Another investigation into reclassification ability was conducted by Sharp and Cole (Unpublished report presented in Cole and Scribner, 1974) among the Yucatan of Mexico. The subjects consisted of children and young adults. The children were divided into 6 to 8 year olds (first-grade), 9 to 10 year olds (third-grade), 12 to 13 year olds (sixth-grade), and a group of teenagers (15 to 20 year old) who had attended school for no more than three years. The stimuli consisted of cards bearing pictures of geometric shapes (circles and triangles), varying in colour (red and black) and number (one and two). On the basis of initial response, it was found that 17% of the first-graders, 47% of third-graders, and 84% of the sixth-graders successfully classified the stimuli. The teenagers on the other hand, averaged 37% indicating that classifying pictorial material is more conditioned by schooling than by age alone.

When subjects were asked to reclassify, the percentage success were as follows: first-graders 3%, third-graders 44%, and sixth-graders 60%. Of the teenagers, those who had one year or less of schooling attained only 8% success while those with two or three years of schooling achieved 28% success. Again the influence of formal school experience on classification behaviour is evident.

Sharp and Cole's (Cole and Scribner, 1974) study employed stimuli that presented opportunity for a third sort but this was not done. Nor do the investigators appear to have controlled other variables besides age and schooling.

In summary, it can be seen that a wide variety of factors seem to influence reclassification behaviour. The familiarity of the stimuli facilitates reclassification even among primitive cultures (Price-Williams, 1962). Among illiterate communities, urbanization is an important factor (Schmidt and Nzimande, 1970). In classifying multi-attributed formal stimuli (Sharp and Cole in Cole and Scribner, 1974), years of schooling appears to be more important than chronological age *per se*.

Since the reclassification issue is important in resolving the preference versus ability controversy, it needs to be more systematically investigated.

In this investigation, reclassification behaviour will be examined among subjects whose chronological age and years of school experience will be controlled.

As far as free classification ability is concerned, there have been wide variations in the stimuli used. In their search to find stimuli familiar to some of the primitive cultures, investigators have used stimuli that have been far too specific to one culture to allow for meaningful generalizations outside the culture (Price-Williams, 1962, Irwin and McLaughlin, 1970). Among the western cultures, formal geometric stimuli have been used more frequently (Denney, 1972a, 1972b). The use of such formal stimuli among Zulus (Schmidt and Nzimande, 1970) yielded results which were consistently below the level of proficiency observed among western children. In comparing performances on two and three-dimensional stimuli, (e.g., Deregowski and Serpell, 1971) further confounding has occurred by changing the presentation mode from real objects to pictures of objects.

Since a wide variety of factors appear to influence classification ability as reported in different studies, it was decided to systematically investigate some of these factors in one study using the same stimuli and experimental procedures on the same group of subjects. In this way it was hoped that some information would be acquired on the relative contributions of the age, stimulus and mode of presentation variables on the attainment of classification ability.

3.5 MATRIX CLASSIFICATION

In matrix classification, the child is required to attend to two attributes of the stimuli simultaneously, and also to recognize how the requirements for similarity are changing in both horizontal and vertical directions. For this reason both Piaget (Inhelder and Piaget, 1964) and Bruner (1967) regard matrix classification as an advancement on free classification ability. In free classification ability, it was noted that there were no right or wrong ways of classifying the stimuli. A response was regarded as successful if it was based on some discernable similarity. The matrix classification tasks, by their nature, are highly structured and the response is either right or wrong.

Techniques for assessing matrix classification ability vary. Traditional Piagetian technique usually involves presenting the subject with a partially completed matrix and requesting the child to complete the rest by choosing the appropriate stimuli that will maintain similarity in horizontal and vertical directions. The techniques employed by Bruner and Kenney (1967) include replacement, reconstruction and transposition. These have already been described in Chapter One.

Bruner and Kenney (1967) investigated matrix classification ability among 50 children, ten each of ages 3, 4, 5, 6, and 7 years. The stimuli consisted of nine plastic beakers varying in height (three) and diameter (three). The assessment procedures adopted included replacement, reproduction and transposition. In each of these, the child was first presented with a complete matrix.

In the replacement procedure, first one, then two then three beakers were removed and the child was required to replace the items in their correct cell. It was found that three and four year olds easily replaced one beaker. This is not surprising since only one cell was empty and one stimulus had to be used. However, when two beakers were removed, 30% of the three and four year olds reversed positions and 55% failed when three beakers were removed. Virtually all the older children (ages five, six and seven) succeeded in replacing all three beakers in their correct cells.

In the reproduction procedure, the completed matrix was scrambled, that is, the beakers were removed from the ruled cardboard and placed to one side. The child was requested to reproduce the original arrangement. It was found that none of the three year olds succeeded. The following rates of success were observed among the remaining age groups: four year olds 10%, five year olds 60%, six year olds just over 70%, and seven year olds 80%.

The third procedure used was transposition. All the beakers were removed from the board. One (the shortest and thinnest) was placed in the cell diagonally opposite to the one it originally occupied. In other words from its original position in the bottom left cell, it was now placed in the top right cell. The child was required to make something like what was there before. Only the six year olds (about 25%) and seven year olds (about 80%) succeeded.

The results suggest that of the three procedures, replacement is the easiest, reproduction of intermediate difficulty and transposition the most difficult. Bruner and Kenney (1967) suggest that children fail on the replacement task because they match the beaker on one dimension, usually height, while ignoring diameter. This inability to simultaneously attend to two dimensions is characteristic of pre-operational thought described by Piaget (Flavell, 1963).

The reproduction task is more difficult because the actual matrix is scrambled. No visual support by way of partial cues (as is typical in the Piagetian technique) is available and the child relies on his memory image of the original matrix. When asked what the children were doing, they often replied that they were trying to remember where the glasses had been before. The reproduction task thus becomes more a test of memory than an assessment of classification ability.

The transposition task is made difficult by two main factors. Firstly, just as for the reproduction task, the partial cues are no longer available. Secondly, as the matrix has to be transposed, memory no longer assists in completing the task. In fact, if the child replaces the beakers by remembering where they had been originally, he would get the task wrong. Only if the child has fully grasped the relationship of similarity on both vertical and horizontal directions and at the same time, is aware of the transposition implied by the single cue provided, can he succeed. Bruner and Kenney (1967) find that by age seven, 80% of the American children succeed.

The replacement and reproduction procedures are too memory-bound to be used as a suitable procedure for assessing matrix classification ability. They do not provide clear-cut information on the actual figuring-out process, that is, the information evaluation and processing that Bruner (1967) regards as the fundamental requirement for the development of classification ability. The transposition procedure provides better information with respect to the underlying rule or ordering principle of the matrix task. The memory factor no longer provides assistance. In fact, memory will actually have a negative effect as explained above.

If any one of the procedures used by Bruner and Kenney (1967) is selected the transposition procedure should prove the best of the three. However, even this procedure has its limitations in that it appears to be more difficult than the traditional Piagetian procedure.

Wei, Lavatelli and Jones (1971) investigated matrix classification as part of their study on the effect of social environment on classification behaviour. Although free classification and matrix classification were studied in the same group of subjects, the stimuli used in the two tasks were different.

The stimuli used in the matrix task were pictures of geometric shapes, fish and flowers. The first practice item was a two x two matrix with one cell unfilled. The child had to choose one of four pictures that would successfully complete the matrix. After the practice task the three other tasks were presented. The first was a three x two matrix using pictures of three shapes and two colours. Seven alternatives were provided from which the child had to choose the correct one. The second task was a two x two matrix using pictures of three shapes and two colours. Seven alternatives were provided from which the child had to choose the correct one. The second task was a two x two matrix using pictures of fish varying in colour and direction of motion (moving to right or moving to left). The correct picture was one of six provided. The third task was also a two x two matrix using pictures of flowers varying in colour and size. The correct picture to be chosen was one of eight provided.

The results (read off from graphs as no relevant numerical data are tabulated) showed that at both the kindergarten and second-grade levels, the MC subjects scored higher on the matrix tasks than did the CD subjects. About 60% of the MC second-graders succeeded on all three matrix tasks whilst only about 45% of the CD subjects of the same age succeeded on all three tasks. Among the younger kindergarten subjects about 25% of the MC and 10% of the CD children succeeded on all three tasks. These results indicate that success on the matrix tasks increases with age among both MC and CD children. Also, at each age level, the MC children obtain a higher rate of success than the CD children. Wei, Lavatelli and Jones (1971) also report that CD groups scored lower in verbal justifications than MC groups. For example, of the 45% of the CD second-grade children who succeeded on the matrix tasks, only 25% could give correct justifications. Of the 60% of the MC subjects that succeed all gave correct justifications. This would suggest that the social environment has an important effect on verbal ability.

The above study employed both two x two and two x three matrices. No data are provided as to whether there was any difference in performance between the two types of matrices. Also, as only one cell had to be completed by the subjects in each task, the tasks would appear to be somewhat over-simplified. Perhaps this was necessary in order to elicit some measure of success from the kindergarten children but may have been too easy for the second-graders. However, on a two x two matrix it is not possible to leave more than one cell empty as the necessary cues cannot otherwise be provided.

An improvement in design which would provide information about shades of differences in ability would be to use at least a three x three matrix. In such a situation, a minimum of three cues gives the matrix the required structure. Thereafter, additional cells can be filled in, one at a time, providing the child with assistance in achieving a solution. This procedure would not only provide data on success on matrix classification but also on how soon the child achieves success, in terms of the number of cues needed for success.

Bruner and Kenney's (1967) techniques of replacement, reproduction and transposition were used by MacKay, Fraser and Ross (1970) in two experiments on matrix classification. The subjects in the first experiment consisted of 90 children divided into three age groups of 30 each. The age groups were 6, 7, and 8 year olds. Geometric stimuli, varying in shape (square, triangle, circle) and colour (red, black, and white) and arranged into a three x three matrix were presented to one half of the subjects. The other half of the subjects were presented with an array of open-ended plastic cylinders of uniform colour but varying in height (three) and diameter (three). The two sets of stimuli may be regarded as an attempt to compare matrix performance on two-dimensional (2-D) and three-dimensional (3-D) stimuli. However, as the stimuli belonged to discretely different domains, i.e., the 2-D stimuli were geometric shapes and the 3-D stimuli were real objects, the 2-D comparison may not be directly relevant.

The overall results reported by MacKay, Fraser and Ross (1970) revealed that children performed better on the matrix tasks using discrete variations (shapes and colours) than on the tasks requiring seriation of height and diameter. Also, the children showed a greater measure of success on the reproduction tasks than on the transposition tasks.

The second experiment was conducted among 48 children of ages 5, 6, and 7 years. The stimuli consisted of nine solid wooden cylinders varying in height (three) and colour (three) but of constant diameter. The overall results revealed that 77% of the children succeeded in reproducing the matrix and only 44% in transposing the matrix.

In both the first and second experiments, MacKay, Fraser and Ross (1970) report a steady improvement on the matrix tasks with age. This was true with all types of stimuli used and for both reproduction and transposition techniques.

MacKay, Fraser and Ross (1970) list the following conclusions derived from their investigation:

1. The ability to construct a matrix composed of discrete categories is developmentally an earlier acquisition than the ability to construct one composed of relational variables.

2. A matrix composed of discrete categories in both directions is of equivalent difficulty to one constructed of discrete categories in one direction and a relational variable in the other.

3. A matrix composed of discrete categories is no more easily reproduced than it is transposed, while matrices in which either one or both variables are relational are more easily reproduced than transposed.

4. The majority of children who reproduce the matrix under each condition do so exactly as it is initially presented.

The design used by MacKay, Fraser and Ross (1970) may be improved by selecting 2-D and 3-D stimuli from the same domain. The apparent deficiencies of the reproduction and transposition techniques have already been stated. The completion procedure used by Piaget (Inhelder and Piaget, 1964) and Wei, Lavatelli and Jones (1971) would appear to be a more valid technique of assessing matrix classification ability independently of the influence of memory. These matters will be given attention in the present investigation.

Denney and Cornelius (1975) investigated matrix classification in middle and old age. While the age of subjects may be irrelevant to the present investigation, the assessment techniques used are illuminating. They used two types of matrices, a two x two matrix and a three x three matrix. In the two x two matrix one cell had to be filled in and in the three x three matrix three cells had to be filled in. The stimuli were ink drawings on cards and consisted of geometric shapes of different colours and sizes. In each matrix task, the subjects had to pick the correct stimuli from three to nine alternatives provided.

No data is provided on the relative difficulty of the two x two and three x three matrices. Nor is it clear how the availability of more stimuli than was necessary to complete the task influenced the subjects' responses. Also, no attempt was made to vary the level of difficulty of the three x three matrix by varying the number of cells to be completed by the subject. This issue will receive attention in the present investigation.

In summary, the empirical evidence seems to suggest that matrix classification improves with age. The assessment technique used also seems to influence the degree of success achieved by subjects. Socio-economic factors have also been reported to have an effect on matrix classification responses. (Wei, Lavatelli and Jones, 1971). All these factors will receive attention in the present investigation and an attempt will be made to select stimuli and the appropriate assessment technique which should make a direct comparison of free and matrix classification responses possible.

3.6 CONCLUSION

From the review presented certain issues needing further investigation emerge. Firstly, there is convincing evidence that both free and matrix classification ability increase with age. However, there is conflicting information with regard to the specific ages at which the abilities are manifested. This is not surprising as there have been considerable variations in the cultures studied, the stimuli used, and the experimental procedures adopted. In order to provide a greater degree of cross-cultural generalizability, a study should adopt procedures that are reasonably standardized and select stimuli that are more familiar across cultures. These matters are given attention in the present investigation.

There have been a few attempts to compare free and matrix classification among the same subjects (Wei, Lavatelli and Jones, 1971) but the stimuli have been different. The attempt to compare 2-D and 3-D stimulus effects on matrix classification (MacKay, Fraser and Ross, 1970) has employed 2-D stimuli from a different domain to the 3-D stimuli. As yet no study has systematically compared free and matrix classification ability among the same subjects using the same stimuli. This is another matter that will receive attention in the present investigation.

In the next chapter, the problem area will be highlighted and a methodology derived to answer some of the questions that have arisen.

TABLE 4a : SUMMARY TABLE OF STUDIES REVIEWED

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
PRICE-WILLIAMS, D.R.	1962	Free classification responses as a function of familiarity of stimuli	Educated and non-educated Tiv children ranging in age from 6½ to 11 years	Plants and animals familiar to subjects classified according to free grouping procedure	Essentially Bruner	1. All children successfully classified the objects. 2. Older children reclassified in more ways than the younger children. 3. The literacy factor had little effect on classification responses
KOFSKY, E	1966	Verification of Piaget's age-stage formulations (free classification responses investigates as part of wider study)	10 boys and 10 girls in each of 4, 5, 6, 7, 8 and 9 year old groups (American children of above average intelligence)	Geometric figures varying in shape and colour classified through free grouping and verbal labelling procedures	Essentially Piaget	1. Progressive increase by age in successful free classification responses. 2. Only 40% of 9 year old subjects could form hierarchical classification. 3. The regularities in sequence of development suggested by Piaget did not emerge in this study. Explained in terms of variations in instruction and materials.

TABLE 4a continued....

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
BRUNER, J.S. AND KENNEY, H.J.	1967	Matrix classification as a function of age and assessment	50 children, 10 from each of ages 3, 4, 5, 6 and 7 years	Plastic beakers varying in height and diameter used in replacement, reproduction and transposition of matrices	Bruner	1. With all procedures, success rate improves with age. 2. The order of increasing difficulty of the procedures was replacement, reproduction and transposition.
IRWIN, A.M. AND McLAUGHLIN, D.H.	1970	Stimulus effects on free classification responses	School children and adult farmers of the Mano tribe	Unfamiliar stimuli comprised 2-D representations of geometric figures varying in shape and colour. Familiar stimuli comprised bowls of rice varying in size of bowls, type and polish of rice. Free grouping procedure used.	Eclectic	1. School children classified geometric stimuli better than did the adults. 2. Adults classified bowls of rice as well as school children classified geometric stimuli.

TABLE 4a continued....

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
MACKAY, C.K., FRASER, J. AND ROSS, I.	1970	Variations in stimuli and experimental procedures and their effect on matrix classification (Two experiments)	1. 30 subjects of each of ages 6, 7, and 8 years. 2. 16 subjects of each of ages 5, 6, and 7 years	2-D: Geometric figures varying in shape and colour. 3-D: Open ended plastic cylinders varying in weight and diameter Bruner and Kenney (1967) procedure used. Solid wooden cylinders of constant diameter but varying in colour and height. Same procedure as above.		1. Children performed better on stimuli using discrete variations (shape and colour) than on stimuli requiring seriation of height and diameter. 2. Reproduction procedure was found to be easier than transposition. 3. Matrix composed of discrete categories in both directions is of equivalent difficulty to one constructed of discrete categories in one direction and a relational variable in the other

TABLE 4a continued....

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
SCHMIDT, W.H.O. AND NZIMANDE, A.	1970	Effect of western type of schooling on classification behaviour	Children with and without western type schooling, illiterate farm workers and urban workers. Age of children ranged from 5 to 14 years. Workers age ranged from 20-60 years	Geometric figures varying in shape and colour and cards bearing pictures of these figures were used in a free grouping procedure.	Atheoretical	1. Zulu children without schooling and adult illiterate farm workers show an overwhelming preference for colour. 2. About 60% of illiterate Zulu workers could reclassify the stimuli a second time but very few could do so a third time. 3. Among rural school children, the percentage of children re-classifying three times increased with age.
OKONJI, O.M.	1971	The effects of familiarity of stimuli on classificatory behaviour	138 Ibusa children, 105 Glasgow children ranging image from 6 to 12 years.	Animals (plastic models) familiar to both groups and a collection of objects familiar to the Ibusa but not the Glasgow children. A free grouping procedure used.	Bruner	1. Use of equally familiar stimuli produces no differences in performance of children from the two cultures. 2. Stimuli familiar to the Ibusa but not to the Glasgow children result in superior performance by the Ibusa.

TABLE 4a continued.....

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
WEI, T.T.D., LAVATELLI, C.B., AND JONES, R.S.	1971	Effect of age and social environment of free and matrix classification responses	80 children divided into four groups of 20, made up of 5 year old and 7 year old. Middle class and culturally deprived children	Miniature toy objects including people, animals, houses and eating utensils used in free grouping procedure. Pictures of geometric figures, fish and flowers used in completion of matrices.	Piaget	1. Older subjects performed better than younger subjects on both free and matrix classification tasks. 2. MC subjects scored higher than CD subjects on both tasks. 3. MC subjects showed greater improvement with age than did CD subjects.
DENNEY, N.W.	1972a	Developmental changes in free classification ability as a function of experimental procedures	6 groups of subjects of ages 2, 4, 6, 8, 12 and 16 years.	38 wooden blocks varying in shape and colour. Piagetian free grouping and Vygotsky's verbal labelling procedure used.	Piaget	Free grouping procedure produces a larger variety of responses than the verbal labelling procedure. 2. Generally, performance improved as age increased.

TABLE 4a continued....

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
DENNEY, N.W.	1972b	Verifications of Piaget's age-stage formulations	36 middle class American children from each of ages 2, 3 and 4 years	32 cardboard figures varying in shape, colour and size. Free grouping procedure used.	Piaget	1. Significant relationship between age and type of response. 2. 48% of 4 year old subjects gave multidimensional responses. 3. American children develop classification ability earlier than Genevan children.
MALLET, J. AND DREW, C.J.	1974	Effects of age and socio-economic status on free classification behaviour	Third and sixth grade children of low and middle SES. Mean age of third grade children was 8 years and of sixth grade children, 12½ years.	21 objects including household, play and food items used in a free grouping procedure	Bruner	1. Third grade subjects of both SES groups classify more on concrete basis than do sixth grade children. 2. Sixth grade children tend to give more conceptual responses. 3. Significant age x SES interactions were observed in the free classification responses of the children.

TABLE 4a continued.....

AUTHOR	DATE	AREA OF STUDY	SUBJECTS	STIMULI AND PROCEDURE	THEORETICAL ORIENTATION	MAJOR FINDINGS
SHARP, D.W., AND COLE, M.	1974	Effect of age and school experience on the classification of pictorial stimuli	Yucaban subjects of first, third and sixth grades and a group of teenagers with no more than three years of formal schooling	Cards bearing pictures of geometric figures varying in shape, colour and number. A free grouping procedure was used.	Bruner	1. Among school children, the percentage of successful free classification responses improved as age of subjects increased. 2. Teenagers with three years or less of formal schooling averaged a lower rate of success graders. 3. 60% of the sixth graders successfully reclassified the stimuli. Teenagers with 2 to 3 years of schooling averaged 28% while teenagers wtih one year or less or schooling averaged only 8%.
DENNEY, N.W. AND CORNELIUS, S.W.	1975	Matrix classification in middle and old age	Middle aged, community elderly and institution-alized elderly subjects	Three-factor and 2-factor matrices were employed using the completion procedure. No information available about the actual stimuli (Study reviewed because of design of matrix task)	Piaget	1. Middle-aged subjects performed better than elderly subjects. 2. Education level of subjects influenced performance. 3. Institutionalized elderly performed worst of the three groups.

CHAPTER FOUR

DESIGN OF THE STUDY

4.1 INTRODUCTION

The general aims of the investigation as presented in Chapter One, were to empirically determine age changes in classification behaviour and to identify some of the variables affecting classification. From the previous chapter which reviewed the literature, it is evident that many features need further investigation. In this chapter, the many problem areas will be highlighted and the derived methodology for this research presented.

4.2 THE PROBLEM

For easy reference, the problem will be discussed under the same headings used in the chapter on review of literature, namely, developmental changes, choice of stimulus materials, and re-classification ability. The issues involved in developmental changes and the choice of stimuli apply to both free and matrix classification ability. However, the features involved in re-classification ability, are by their nature, applicable to only free classification ability. In a typical matrix task requiring the subject to complete the matrix in accordance with the cells already filled in, there can be only one correct response. Therefore, it makes no sense to ask the subject to complete the matrix in some other way. However, the child's ability to recognize attributes other than those used in one matrix task, can be assessed by presenting him with other tasks calling for the recognition of different attributes of the same stimuli. For example, if a child can succeed with three tasks, involving size and shape, size and colour, and colour and shape, then it can be concluded that he understands all three class intensions.

The second and third tasks may roughly be regarded as analogous to the second and third reclassification attempts.

4.2.1 Developmental changes in classification behaviour

A number of studies have investigated developmental changes in classification behaviour (e.g., Wei, Lavatelli and Jones, 1971; Denney, 1972a, 1972b; Tatarsky, 1974; Carson and Abrahamson, 1976). These studies have varied widely with respect to stimulus materials used experimental procedures adopted, the age of subjects tested, and the educational and cultural backgrounds of subjects. Such variations make it difficult to generalize the findings to Indian children in South Africa. No research has as yet been conducted on the classification abilities of Indian children who would appear to be more westernized than the primitive tribes studied by Price-Williams (1962), Bruner, Olver and Greenfield (1966), Irwin and McLaughlin (1971), Sharp (1971), to name a few. Wei, Lavatelli and Jones (1971), report a two-year advantage in classification ability that American children show over Genevan children. It is not known how the Indian child shapes in relation to children of other cultures.

Research among Indian children is urgently needed to shed some light on this problem, especially in the light of Bruner's (1967) theory where cultural heuristies are seen to play an important role in classification ability and the Indian child can be regarded as lying in between the Western and traditional primitive populations studied.

The majority of investigators have studied children under the age of ten years of age (e.g., Wei, Lavatelli and Jones, 1971; Denney, 1972a; Kofsky, 1966). According to Inhelder and Piaget (1964), true classification ability is only reached by eleven years of age. Some studies (Price-Williams, 1962; Schmidt and Nzimande, 1970; Denney, 1972a) have included children over the age of ten as well as adults. However, in such studies the main hypotheses have been in relation to variables other than age changes. Consequently, the findings from most investigations are restricted in the sense that they describe age changes in classification behaviour only among children who have yet to reach true classification ability. How these responses change later can only be studied by including children over eleven years of age.

Another issue in relation to age changes in classification behaviour that requires attention is the question of age differences. The tendency has been to use two-year intervals (Denney, 1972a; Wei, Lavatelli and Jones, 1971) or even only one year intervals (Denney, 1972b; Kofsky, 1966). Schmidt and Nzimande (1970) grouped their subjects into 4 to 6, 7 to 8, 9 to 10, and 13 to 14 year olds. This permits a fair amount of overlap between successive age groups, especially as Piaget (1964) states that the ages at which a child advances from one stage to the next is only approximate. To demonstrate age differences more clearly a wider difference in age than one or two years seems indicated.

In the present investigation, attempts were made to resolve some of the abovementioned problems in order to obtain a clearer picture of age changes in classification ability. Two groups of subjects aged approximately 9 years (younger group) and approximately 12 years (older group) were tested. The intelligence level, the educational level, as well as environmental and socio-economic variables were controlled.

4.2.2 Choice of stimulus materials

Several problems in selecting the stimulus materials can be identified. Firstly, it has already been stated in the previous chapter that familiar materials promote successful classification (Price-Williams, 1962; Irwin and McLaughlin, 1970). The variations in the concept of familiarity and its accompanying difficulty in making generalizations from these studies have also been described. In order to make the stimuli familiar to the child and at the same time avoiding using items that are too specific to one culture, in this study it was decided to use geometric forms. Circles, triangles, squares, spheres, prisms and cubes were selected. All school-going children are reasonably familiar with these, as these are frequently encountered in their formal education. Of these, the three-dimensional real objects such as cubes, spheres and prisms may be regarded as more familiar since the child encounters these even before going to school. All children have played with a ball or with building blocks of some sort, and these are therefore reasonably familiar across cultures. The two-dimensional geometric shapes, namely the squares, circles and triangles were equivalents of the cubes, spheres and prisms. These may be regarded as less familiar to the children as they are no more than representations of real objects. These are less likely to be encountered outside formal education. The advantage of the stimuli chosen is that these can be used among most cultures, and have, indeed, been used in some form by others (e.g., Inhelder and Piaget, 1964; MacKay, Fraser and Ross, 1970). The stimuli selected could provide information on both the familiarity-unfamiliarity issue as well as on the three-dimensional real object versus two-dimensional representation of objects issue.

The second problem involved the way in which the stimuli are presented to the subjects. Here too, variations in presentation methods make generalization from one study to another difficult. Stimuli have been projected on a screen (Osler and Madden, 1973). Colour photographs of objects have been used (Carson and Abrahamson, 1976). Paper cut-outs have been mounted on boards (Bruner 1966; Deregowski and Serpell, 1971). Some investigations have used actual objects (MacKay, Fraser and Ross, 1970; Angelev and Kahn, 1976). It has already been shown in the previous chapter that the method of presentation does have an effect on the child's response. In order to control the variability responses due to variations in methods of presentation it was decided to present each child with the actual objects in three-dimensional forms (cubes, prisms and spheres) and two-dimensional shapes (squares, triangles and cubes).

4.2.3 Reclassification

In most studies on classification ability, subjects are asked to classify an array of stimuli. On the basis of a single response, generalizations have been made about the basis for sorting at different age levels (e.g., Corah, 1964, Suchman, 1966). The limitations of such generalizations have already been discussed in Chapter 3.

Studies on reclassification show that older subjects reclassify more frequently than younger subjects (Price-Williams, 1962; Kofsky, 1966; Schmidt and Nzimande, 1970). However, little information is available with regard to the number of different ways in which the stimuli were reclassified in relation to the possibilities offered by the array. For example, if a stimulus array was made up of three salient features, no information is available on how many subjects could reclassify in three different ways, or two different ways or could only do it one way.

In this investigation it was decided to ask subjects to reclassify three times all together, since the stimuli possessed three salient features, colour, shape and size. If a child could classify successfully in different ways, then his first trial is merely a reflection of his preference for a particular dimension. The subsequent trials are necessary in order to decide whether the response on the first trial was a reflection of the child's preference for a particular stimulus attribute, or an indication of lack of classification ability. Reclassification trials are therefore, essential to determine this preference versus ability issue.

A child who makes a complex, multi-dimensional response on the first trial, for example a shape x colour response with size seriated, has no alternative way of reclassifying the stimuli except to fall back on a less sophisticated two-dimensional or uni-dimensional response on subsequent trials. In such an instance, the reclassification trials cannot provide meaningful information. However, in order to maintain a standardized procedure, reclassification trials were given to all subjects.

If a child makes a uni-dimensional response based on colour for example, on the first trial and fails to reclassify on the basis of the other salient attribtues on the second and third trials, it may be concluded that the child does not yet recognize the other salient attributes, and thus has not yet attained true classification ability.

Keeping in mind the problems discussed thus far, the study was designed that would fulfil the aims of the investigation. This is discussed in detail in the following section.

4.3 DESIGN OF THE STUDY

In discussing the problems requiring attention mention has been made of ways in which these problems could be overcome. These are elaborated below. In doing so, attempts are made to justify each decision taken.

4.3.1 Subjects

The subjects were 30 males and 30 females from each of standards I and IV, selected randomly from four primary schools in the Arena Park area of Chatsworth. In order to control certain unwanted variables, certain criteria were applied to restrict the population from which the subjects were chosen.

Firstly, in order to control for socio-economic background only children from middle class homes were included in the population to be sampled. The socio-economic level was established by obtaining a rating from class teachers as well as by the researcher interviewing each child to confirm the teachers' rating. The father's occupation was taken as the criterion for determining the socio-economic class. The sample included children of professional men such as doctors and teachers. Some of the parents owned small businesses and manufacturing concerns in and around Durban. Parents employed in industry had reached supervisory and managerial levels. Although not a fool-proof method, parents' occupation as a measure of socio-economic class has proved useful (Ramphal, 1969).

In order to control the IQ of the subjects, the population included only those children who occupied the top ten positions in their class in the previous (June) examination. Children who had failed in any previous year, or who were not of normal age for their class were excluded from the investigation. To obtain clearer age difference, the gap between the younger and older group was made approximately three years. Initially the sample was selected from Std I and Std IV. However, as testing was not completed by the end of the year (having begun in September) some of the children were tested when in Std II and V. Fortunately, no child selected the previous year had to be replaced because of failure or transfer to another school.

The mean ages and standard deviations of sample are tabled below.

TABLE 5 : MEAN AGES AND STANDARD DEVIATIONS (IN MONTHS) OF THE SAMPLE INVESTIGATED

STD	AGE GROUP	SEX	$\bar{X}$	S	N
IV-V	OLDER	MALE	143,97 (12 yrs)	4,91	30
		FEMALE	141,00 (11 yrs 9 mths)	2,74	30
I-II	YOUNGER	MALE	108,23 (9 yrs)	3,95	30
		FEMALE	108,63 (9 yrs)	4,48	30

From the above table it can be seen that there was an age difference of approximately three years between the younger and older subjects, and the males and females in each group were more or less of equal ages.

In selecting the sample in the way described, it was hoped to control unwanted subject variables and to minimize their effect on any possible age differences.

4.3.2 Stimulus materials

The reasons for the choice of geometric shapes and forms have already been presented. There were a total of 27 two-dimensional (2-D) stimuli and 27 three-dimensional (3-D) stimuli. The 2-D stimuli varied in shape (triangle, circle, square), size (small, medium, large), and colour (red, green, blue). Each piece was cut from three millimetre thick hard board. The 3-D stimuli were constructed out of solid soft wood to correspond in size and colour on a one-to-one basis with each of the 2-D stimuli. They consisted of prisms, spheres and cubes. All the pieces were painted with high gloss enamel paint to ensure even colour saturation. Details are tabled below.

TABLE 6 : DETAILS OF SHAPES, SIZES, AND COLOURS OF THE TWO-DIMENSIONAL STIMULI

SHAPE	SIZE	COLOURS
Triangle	Vertical Height 2,5 cm	Red, Green, Blue
Triangle	Vertical Height 5,0 cm	Red, Green, Blue
Triangle	Vertical Height 7,5 cm	Red, Green, Blue
Circle	Diameter 2,5 cm	Red, Green, Blue
Circle	Diameter 5,0 cm	Red, Green, Blue
Circle	Diameter 7,5 cm	Red, Green, Blue
Square	2,5 cm	Red, Green, Blue
Square	5,0 cm	Red, Green, Blue
Square	7,5 cm	Red, Green, Blue

All the materials were professionally turned out by a woodwork student at the Springfield College of Education and were made to the researcher's specifications. Painting was done by the researcher who repainted the stimuli periodically during testing to ensure consistency in colour saturation.

The advantages of the stimuli selected may now be summarized. Firstly, within the same conceptual domain (i.e., geometric shapes), the familiarity-unfamiliarity issue and the three-dimensional real objects versus two-dimensional representation issue may be investigated. While these issues have been singly investigated (Price-Williams, 1962; MacKay, Fraser and Ross, 1970), no study has investigated the combination of these issues using the same stimulus domain. Secondly, both the two-, and three-dimensional stimuli can be used without modification on both free and matrix classification tasks, making comparison more meaningful. A three x three matrix may be formed by taking a combination of any two of the three attributes (shape, colour, size) of the stimuli. Matrix and free classification ability have not been previously investigated among the same subjects using the same stimuli.

4.3.3 Experimental procedure

Each child was tested individually, in privacy in a room provided for the purpose by the school principal.[1] This was often a classroom cleared for the day to accommodate the researcher. In one school the library was used for the entire duration of the testing.

Each child was tested over two sessions, each lasting approximately twenty five minutes. As each child entered, he was asked to sit and a minute or so (depending on the state of nervousness apparent) was spent in small talk to put the child at ease. The conversation

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1. The researcher wishes to acknowledge the cooperation and generosity of the school principals involved in making a room available. The principals went out of their way to make a room available for the day's testing and instructed the caretaker to assist in arranging the room to the researcher's requirements. In the Indian school situation where there is a critical shortage of space, and children take turns in outdoor activities to accommodate others, this assistance is deeply appreciated.

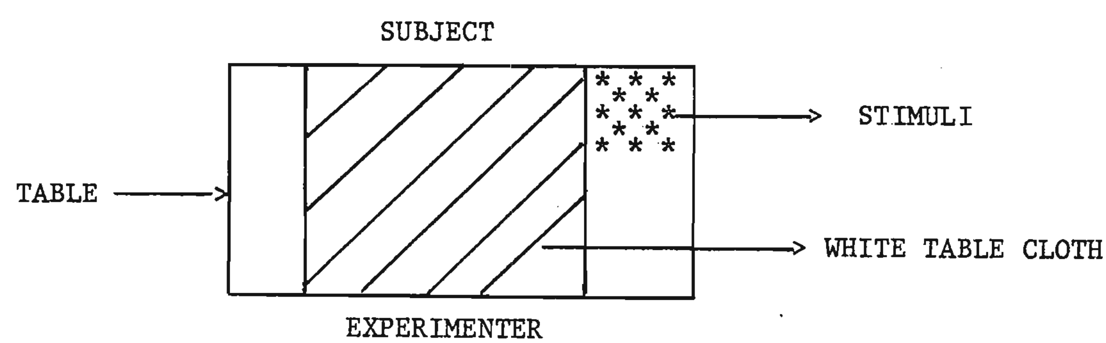
usually involved the researcher complimenting the child on his dress, appearance, or his high position in class. Rapport was easily established as the child had already met the researcher earlier during sample selection when the child was interviewed about his parent's occupation.

Once rapport was established, testing proper was commenced. During one session, the two-dimensional stimuli were used and during the other session the three-dimensional stimuli were used. The order was randomly varied so that one-half of the subjects were presented the 2-D stimuli first whilst the other half worked with the 3-D stimuli first. With both types of stimuli, the free classification task was done first and the matrix task second.

4.3.3.1 Free classification

The subject was seated facing the experimenter across a table. The stimulus array was arranged randomly on one side of the table to the left of the subject. In front of the subject a white table cloth was pinned to the table. The subject had to arrange the stimuli on the table cloth. The seating arrangement is diagrammed below.

Fig. 2 Diagrammatic representation of experimental setting



The white table cloth was used to provide high contrast for the photographs which were taken of the subjects' responses. It also provided constraint on the surface on which the child could make his response.

The instructions were standardized and repeated verbatim to each subject. "Now we are going to play some games. I want to see how you play these games. Over here (indicating the stimuli to his left) are some things you have seen before. Have you? All right. Now listen to me carefully.

> *I want you to put these things together on this table cloth in such a way that all the things that are the same are put together. You can do it any way you like. I want to see how you do it.*

Do you understand? (If questions were asked, the part of the instruction in italics was repeated.) There are no right or wrong ways of doing this. You can do it any way you like. Please put together those things that go together. I want you to work as quickly as you can. When you have finished, please tell me. Ready? Begin."

When the child indicated he had finished he was asked to justify his behavioural response. "Can you tell me why you put these things together in this way? How do these things go together?" The child's response was photographed for later reference.

The stimuli were then replaced in random order, to the left of the child. The following instruction was then given. "You did it very nicely before. Now I want to see if you can do it another way. Put these things together in a different way this time. Remember, all those things that go together must be put together. Ready? Begin." The child's responses, behavioural and verbal, were recorded as before. The child was requested to reclassify a third time, being given the same instructions as for Trial 2. Again, his responses were recorded in the usual way.

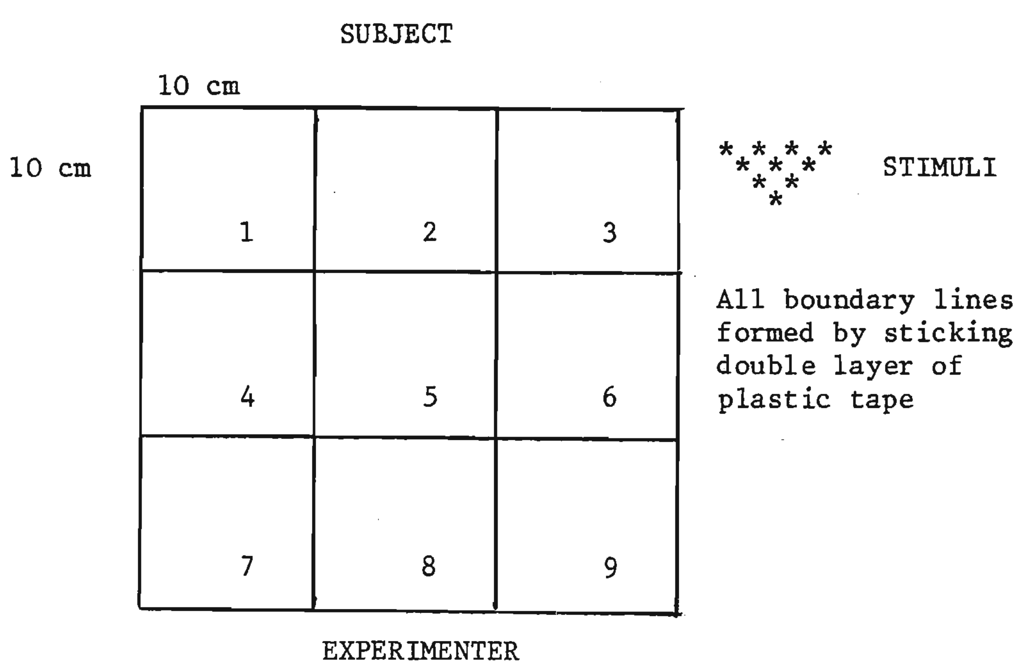
When the free classification tasks were completed the matrix tasks commenced.

4.3.3.2 Matrix classification

As with the free classification tasks, the child performed the matrix tasks with 2-D stimuli on one day and the 3-D stimuli on the next day. The order was randomly varied as indicated before. In other words during one session the child did both the free classification and matrix tasks with 2-D stimuli and during the other session he did both tasks with 3-D stimuli. With each set of stimuli both tasks were done on the same day.

The basic physical experimental arrangement was the same as for the free classification tasks, with one difference. A white sheet of cardboard, 30 cm x 30 cm, glued on to hardboard backing, and marked into 9, 10 cm squares, was used for the child's responses. The boundary lines of each square were made by a double layer of 5 mm wide plastic tape stuck on. The squared board was placed over the table cloth in front of the child. The stimuli were arranged in random order to the left of the child. Although only 9 stimuli were required in any one task, all 27 were available for him to make a selection. The response board is diagrammed below.

Fig. 3 Diagrammatic representation of response board used in matrix task



(N.B. The cell numbers did not appear on the board. They are filled in here for ease of reference.)

The child's attention was drawn to the response board and he was asked to observe the experimenter. The experimenter slowly and deliberately selected three stimuli from the array and filled in cells 1, 5, and 9 in that fixed order. The stimuli were predetermined in terms of the matrix being tested.

The following standardized instructions were then given:

"I have filled in some of the squares with these things (indicating three on board). Now I want you to fill in the rest of the squares (indicating blank cells) by picking the right ones from here (indicating remainder of stimuli). You must do it in such a way that all the things in these rows (indicating horizontally) are the same in some way. Also, all the things in these rows (indicating vertically) must also be the same in some way. Do you follow me? (If query, instructions repeated.) Ready? Begin."

The child's response was recorded on the answer sheet. The child was asked to justify his response, using the same pattern of questions as for free classification.

If the child failed to correctly solve the matrix with three prompts, he was told, "Now let me help you. Watch. I will remove those you put in. (All but those initially put in by the experimenter removed one at a time.) See? I am going to put in one more to make it easier for you. (Cell 3 filled in.) Now see if you can fill in these (indicating remaining) squares. Remember, all the things in these rows (horizontal) must be the same in some way. Also, the things in these rows (vertical) must be the same in some way too. OK, Begin." Subjects' responses and verbal justification were recorded as before.

If child failed with 4 prompts, the whole procedure was repeated with one additional cell (cell 7) being filled in. If the child failed with 5 prompts, the task was discontinued. The child was regarded as being unable to solve that particular matrix.

At each session, and, consequently, with each set of stimuli (2-D and 3-D), three matrix tasks were given. These were, in a fixed order, shape x colour, colour x size and shape x size. In any given matrix task, the non-salient attribute was kept constant. For example, in the shape x colour matrix, size was kept constant. The small, medium, or large stimuli were used, randomly varied so that each size was used by one-third of the subjects. Similarly in the shape x size matrix, colour was kept constant, each colour being presented to one-third of the subjects. In the colour x size matrix, shape was kept constant.

The session ended when the child had worked through the third matrix task. There were two sessions. In each session the free classification tasks were followed by the matrix tasks. The two sessions differed only in respect to the type to stimuli used.

The second session occurred about three weeks after the first session. The actual gap between the two sessions varied from 17 days at the soonest to 27 days at the latest. At the second session, the procedure was exactly the same as for the first session with the only difference being that the other set of stimuli were used.

4.3.4 Overview of design

From the preceeding discussion, it will be noted that the design of the study was a 2 x 2 x 2 x 2 factorial design with repeated measures on the last two factors. The independent factors were age (9 and 12 year olds) and sex. There were 30 subjects in each group making a total sample of 120. Each subject was required to do both the free and matrix classification tasks. Each task was done with both two- and three-dimensional stimuli making up the 2 x 2 x 2 x 2 factorial design. Subjects, therefore, performed four tasks, namely, free-classification with 2-D stimuli, free classification with 3-D stimuli, matrix with 2-D stimuli, and matrix with 3-D stimuli. In each task the subject was required to make three behavioural responses. In each free classification task the subject was required to classify the stimuli in three different ways. In the matrix tasks, the subjects had to complete three matrices, the first employing the dimensions of colour and shape, the second, colour and size, and the third, size and shape. Each subject, therefore, made twelve behavioural responses, six on free classification and six on the matrix. Each of the twelve behavioural responses had to be verbally justified. The overall design of the study is diagrammed.(See page 82)

In summary each of the 120 subjects made a total of 24 responses, 12 behavioural and 12 verbal. At the conclusion of the field work, 2 880 separate responses (120 x 24) had to be scored and collated before being subjected to statistical analyses. How the responses were scored and collated will be discussed in the next chapter.

Fig. 4 Diagrammatic representation of design of the study

SUBJECTS		9 YEAR OLD		12 YEAR OLD	
SEX		MALE	FEMALE	MALE	FEMALE

SESSION 1 2-D STIMULI

Free classification Trials 1, 2, 3

Matrix : Shape x Colour, Colour x Size, Shape x Size

SESSION 2 3-D STIMULI

Free Classification Trials 1. 2. 3

Matrix : Shape x Colour, Colour x Size, Shape x Size

Sessions 1 and 2 randomly varied.

CHAPTER FIVE

RESULTS : PRELIMINARY CONSIDERATIONS

5.1 INTRODUCTION

From Chapter Four, it was noted that the investigation employed basically an age x sex x task x stimuli factorial design. The 120 subjects tested gave a total of 1 440 behavioural responses and the same number of verbal justifications. Before the responses could be analysed statistically, they had to be scored and collated. The techniques for scoring the responses received attention first.

5.2 SCORING OF RESPONSES

The procedure adopted for scoring the free classification behavioural responses differed from the one used in scoring the matrix responses. This was necessitated by the inherent differences in the nature of the responses that the subjects were required to make. The different scoring procedures used are discussed below.

5.2.1 Scoring: Free classification behavioural responses

The free classification behavioural responses were scored, in four different ways, each aimed towards specific objectives.

The first method of scoring the free classification responses consisted of simply counting the number of responses based on similarity. The responses based on similarity were regarded as successful, irrespective of whether they were uni-dimensional (based on a single attribute of the stimulus, e.g., colour or shape or size), or whether they were multi-dimensional (based on a combination of two or all three attributes). In other words a response based on colour alone was given the same status as one based on colour and shape. A response was categorized unsuccessful if there was no recognizable pattern of similarity, or if the subject failed to use all the stimuli in the array. The responses of every subject of each age group for each type of stimuli across three trials was scored in the above way. The data obtained are summarized below.

TABLE 7 : SUMMARY TABLE OF SUCCESSFUL AND UNSUCCESSFUL FREE CLASSIFICATION RESPONSES OF 120 SUBJECTS (DIVIDED INTO AGE, SEX, AND TYPE OF STIMULI) ACROSS THREE TRIALS

AGE GROUP	SEX	N	TRIALS	TYPE OF STIMULI			
				2-D		3-D	
				SUCCESSFUL	UNSUCCESSFUL	SUCCESSFUL	UNSUCCESSFUL
Younger	Females	30	1	28	2	29	1
			2	27	3	28	2
			3	24	6	24	6
Younger	Males	30	1	28	2	28	2
			2	24	6	25	5
			3	24	6	24	6
Older	Females	30	1	30	0	30	0
			2	29	1	29	1
			3	26	4	30	0
Older	Males	30	1	30	0	30	0
			2	29	1	29	1
			3	30	0	29	1

The second method of scoring involved differentiating the successful responses into uni-dimensional and multi-dimensional responses. All the responses categorized unsuccessful were eliminated for this analysis. Uni-dimensional responses were those based on a single attribute of the stimulus. For example, a child who divided the stimuli into three classes on the basis of size, or shape, or colour, had his response categorized uni-dimensional. A typical uni-dimensional response is diagrammed in Fig. 5. (See page 85).

Fig. 5 Diagrammatic representation of a typical uni-dimensional response

SQUARES	TRIANGLES	CIRCLES
Small Blue	Large Red	Large Green
Medium Red	Medium Blue	Medium Red
Large Red	Large Green	Small Red
Small Green	Medium Red	Small Blue
Medium Blue	Small Green	Medium Blue
Large Green	Small Blue	Medium Red
Medium Green	Large Blue	Large Red
Large Blue	Small Red	Medium Green
Small Red	Medium Green	Small Green

In the above response, the attribute attended to was shape. Having decided on the attribute, the subject grouped all the items of similar shape into one class. The sizes and colours were randomly grouped together. A uni-dimensional response of this type is interchangeably referred to as a simple response in the ensuing discussion.

A response was categorized multi-dimensional if it was based on two or all three salient attributes of the stimuli. Typical two-dimensional responses were based on colour and shape, or colour and size, or size and shape. Below is diagrammed a typical colour x shape response, where size has been ignored.

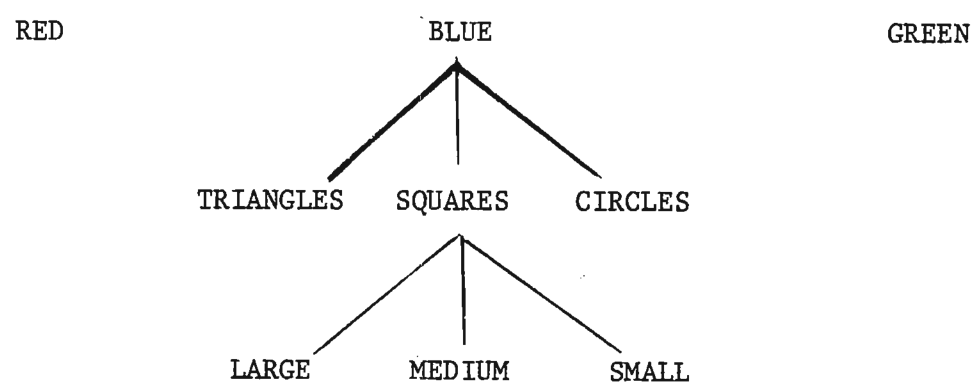
Fig. 6 Diagrammatic representation of a typical colour x shape response

	RED	BLUE	GREEN
SQUARES	Large Small Medium	Small Medium Large	Large Small Medium
TRIANGLES	Small Large Medium	Medium Large Small	Medium Small Large
CIRCLES	Medium Large Small	Small Large Medium	Medium Large Small

It will be noted that once the two attributes of colour and shape have been identified, no attention is given to size within each class.

The most sophistivated response given by the child took into account all three salient attributes of colour, shape and size. Such a response consisted of nine classes based on colour and shape with the sizes seriated in each class (See Fig. 7).

Fig. 7 <u>Diagrammatic representation of a typical three-dimensional response</u>



The sub-classes of triangles and circles were formed in exactly the same way as the sub-class of squares. The classes of red and green were exactly as the class of blue which has been fully developed in the diagram.

The information on the number of uni-dimensional and multi-dimensional free classification responses thus obtained are presented below. (See Table 8)

TABLE 8 : SUMMARY TABLE OF UNI-DIMENSIONAL AND MULTI-DIMENSIONAL FREE CLASSIFICATION RESPONSES OF SUBJECTS (DIVIDED INTO AGE AND SEX) ON 2-D AND 3-D STIMULI ACROSS THREE TRIALS

AGE GROUP	SEX	TRIALS	TYPE OF STIMULI					
			TWO-DIMENSIONAL			THREE-DIMENSIONAL		
			N	UNI-DIMENSIONAL	MULTI-DIMENSIONAL	N	UNI-DIMENSIONAL	MULTI-DIMENSIONAL
Younger	Females	1	28	22	6	29	26	3
		2	27	22	5	28	17	11
		3	24	16	8	24	13	11
Younger	Males	1	28	15	13	28	18	10
		2	24	18	6	25	15	10
		3	24	15	9	24	11	13
Older	Females	1	30	13	17	30	19	11
		2	29	13	16	29	15	14
		3	26	14	12	30	16	14
Older	Males	1	30	9	21	30	11	19
		2	29	17	12	29	17	12
		3	30	16	14	29	12	17

Note that Table 8 has unequal N's as the unsuccessful responses were excluded.

The above data (Table 8) was also used to examine reclassification behaviour.

It will be noted that the above method of scoring the free classification responses yielded frequency counts and thus belong to the nominal scale of measurement. These could only be analysed through non-parametric statistical techniques (Downie and Heath, 1976).

It was decided to quantify the data to make it amenable to parametric analysis as well. The justification for this procedure is presented in the next section dealing with statistical analyses. However, it could be noted that the data have been quantified in this manner by many previous investigators working in this area (e.g., Kofsky, 1966; Wei, Lavatelli and Jones, 1971). This is usually done by awarding points to specific responses in various ways. The procedure adopted in this investigation is described below.

1. Zero point was awarded for each incorrect/incomplete response. For example, a response in which all the stimuli were not used was awarded a zero point.

2. One point was awarded for each response based on similarity on one dimension only. For example, a subject who made three classes based on colour was awarded one point for the response. In other words, all simple uni-dimensional responses were awarded one point each.

3. Two points were awarded for each response based on two attributes of the stimulus, for example, shape and colour.

4. Three points were awarded for each response that utilized all three salient attributes of the stimuli.

It should be recalled that each set of stimuli (2-D and 3-D) was employed across three trials, and thus, in terms of the above scoring procedure, on each trial the response could earn a score ranging from zero to three. Therefore, with each set of stimuli, the subject could obtain a score ranging from zero, indicating failure on all three trials, to nine, indicating three-dimensional responses on all 3 trials. For example, a child who gave a uni-dimensional response on Trial 1, a two-dimensional response on Trial 2 and failed to complete Trial 3 using the 2-D stimuli obtained a score of three (1 + 2 + 0 = 3) on 2-D stimuli. The responses obtained with 3-D stimuli were scored in a similar way. The data obtained are summarized below. (See page 89)

TABLE 9 : SEX X AGE X TYPE OF STIMULUS SUMMARY TABLE OF SCORES* OBTAINED BY SUBJECTS ON THE FREE CLASSIFICATION TASKS

		N	2-D STIMULI	3-D STIMULI
Males	9 year olds	30	74	75
	12 year olds	30	111	106
Females	9 year olds	30	65	69
	12 year olds	30	108	104

*Note the minimum score possible for any cell is 0, indicating complete failure by all subjects on all trials, while the maximum would be 270, indicating three-dimensional responses by all subjects on all trials.

The frequency data and the quantified scores were then subjected to appropriate statistical analyses. These are described later in Section 5.3.

5.2.2 Scoring matrix classification behavioural responses

The matrix classification behavioural responses were scored in two ways. A brief review of the experimental procedure will make it easier to follow the scoring techniques.

It will be recalled from Chapter Four that each subject was required to complete three matrices, namely, colour x shape, colour x size, and shape x size, with each set of stimuli. Each task was presented with three, four, or five prompts, depending on the subject's response. Each subject, therefore, attempted six matrix tasks, three with 2-D stimuli and three with 3-D stimuli. The matrix tasks were, by their nature, structured and the subject's responses were either right or wrong. A response was right if the subject selected the correct stimuli and placed them in their correct cells, showing similarity in both horizontal and vertical directions. If the incorrect stimuli were selected or if the stimuli were placed in the incorrect cells, the subject was scored for an error.

The first way of scoring the data simply involved counting the number of subjects who got each matrix problem right or wrong. Since each child was allowed a maximum of three attempts to solve each task, the frequency count took into account whether the problem was solved on the first attempt (three prompts), the second attempt (four prompts) or the third attempt (five prompts). The data are summarized below.

TABLE 10 : SUMMARY TABLE OF NUMBER OF SUBJECTS ACCORDING TO AGE AND SEX CORRECTLY SOLVING EACH TYPE OF MATRIX WITH 2-D AND 3-D STIMULI WITH THREE, FOUR, AND FIVE PROMPTS

AGE GROUP		9 YEAR OLDS						12 YEAR OLDS					
SEX		FEMALES			MALES			FEMALES			MALES		
NO OF PROMPTS		3	4	5	3	4	5	3	4	5	3	4	5
TYPE OF MATRIX	STIMULI												
COLOUR x SHAPE	2-D	7	12	17	6	8	15	9	16	22	15	22	23
	3-D	6	9	14	8	10	15	17	23	27	13	22	23
COLOUR x SIZE	2-D	13	17	17	14	19	21	23	27	28	25	27	28
	3-D	11	17	20	12	20	21	26	29	30	25	28	30
SHAPE x SIZE	2-D	11	13	15	14	17	20	17	23	26	15	25	27
	3-D	14	17	18	12	17	19	24	28	29	18	24	29

The second method of scoring involved quantifying the matrix behavioural responses in much the same way as was adopted for the free classification tasks. Points were awarded for the responses in the following way:

1. Three points were awarded if the subject succeeded at the first attempt on a particular task. In other words if the subject succeeded with the colour x shape matrix with only three prompts, he obtained a score of three for that task.

2. Two points were awarded if the subject solved the matrix on the second attempt. In other words, if the subject failed to solve the problem with three prompts but succeeded with four prompts, he obtained a score of two for that task.

3. One point was awarded if the subject solved the matrix on the third attempt. If he failed to solve the problem on the first and second attempts but succeeded on the third attempt with five prompts, he obtained a score of one for that task.

4. A zero point was awarded if the subject still failed to solve a problem after three attempts (that is, with five prompts).

Each subject was required to solve three matrix tasks with each set of stimuli (2-D and 3-D), and as he could score zero to three on each task, he could obtain a score ranging from zero to nine for each set of stimuli. The data for the group thus obtained are summarized below.

TABLE 11 : SEX X AGE X TYPE OF STIMULI SUMMARY TABLE OF GROUP SCORES* OBTAINED BY SUBJECTS ON THE MATRIX TASKS

		N	2-D STIMULI	3-D STIMULI
MALES	9 Year Olds	30	134	166
	12 Year Olds	30	205	212
FEMALES	9 Year Olds	30	121	124
	12 Year Olds	30	191	231

*The minimum score possible in any cell is 0 indicating complete failure on all three tasks by all subjects. The maximum possible score is 270, indicated a correct response after three prompts on all three tasks by all subjects.

The method used to obtain the data above (Table 11) is meaningful. High numerical scores indicate higher ability than low scores. For example, a score of three on any one problem indicates that the subject solved the problem at the first attempt whereas a score of one indicates that he managed to solve the problem only at the third attempt. In the same way, if a subject obtained a score of six on the two-dimensional stimuli and eight on the three-dimensional stimuli, this would indicate that the subject did better on the latter than on the former. Also, since the free and matrix classification tasks were quantified in exactly the same way, direct comparison of the two was made possible.

Details of the statistical analyses are discussed in Section 5.3.

5.2.3 Scoring: Verbal explanations

In scoring the subject's verbal justifications of his behavioural responses only those behavioural responses that were classed as successful (See 5.2.2) were considered. The rationale for this was that the study was designed to investigate whether or not the subject could adequately explain a successful response. In other words, not only was he required to make a successful response but he was also required to explain how he arrived at the response.

The system of scoring involved awarding a plus (+) to those responses which adequately explained the behavioural response, and a minus (-) to those that did not. For example, if a subject gave a uni-dimensional colour response in the free classification task and justified the response with reference to colours being the same, he received a +. If he gave a colour x shape response, and explained it in terms of both colour and shape, he again received a plus. However, if he gave the same colour x shape response but failed to justify it in terms of both colour and shape, referring to only one salient feature, or referring to unrelated reasons, he was awarded a minus (-). A + rating was awarded only for those responses that adequately explained the behavioural response. Therefore, a plus indicated that the subject's behavioural response and his verbal explanation were consistent. If the subject's behavioural response was superior, i.e., multi-dimensional, and his explanation uni-dimensional, he was given a minus. Minus scores therefore indicated that the subject was functioning behaviourally at a higher level than he was doing verbally.

In the matrix, the same rationale applied. Obviously, the subject who solved a matrix had considered two attributes simultaneously. In order to be scored + he had to explain his behaviour with reference to both attributes. If he could not, he was scored minus.

The data obtained in terms of frequences of pluses and minuses are summarized below.

TABLE 12 : AGE X SEX X STIMULI X TASK SUMMARY TABLE OF THE FREQUENCY* OF ADEQUATE (+) AND INADEQUATE (-) VERBAL JUSTIFICATIONS OF BEHAVIOURAL RESPONSES OF THE GROUPS

		FREE CLASSIFICATION				MATRIX CLASSIFICATION			
		2-D		3-D		2-D		3-D	
SEX	AGE	+	-	+	-	+	-	+	-
MALES	9 Year Olds	50	26	44	34	41	15	41	15
	12 Year Olds	49	40	51	37	50	28	72	10
FEMALES	9 Year Olds	54	23	56	25	33	30	37	17
	12 Year Olds	45	41	65	24	65	15	78	7

* The minimum possible frequency in each cell is 0, indicating that all the behavioural responses were either adequately justified (- = 0) or inadequately justified (+ = 0). The maximum frequency in any cell is 90, indicating that all 30 subjects in the group gave a successful behavioural response and also gave adequate (+ = 90) or inadequate (- = 90) justifications.

The information tabled above was used in the subsequent analysis to examine this aspect of the study.

5.3 CHOICE OF STATISTICAL TECHNIQUES

From the preceeding discussion, it can be seen that the data obtained were of two kinds. Firstly, the frequency data collected could only be analysed through non-parametric techniques. According to Downie & Heath (1976), the only non-parametric technique of hypothesis testing applicable to frequency (nominal) data is the chi-square test. This statistical technique is the one most frequently used in the studies reported in this area (e.g., Denney, 1972a; 1972b; Fitzgerald, 1977).

The choice of a specific model of the chi-square test required consideration. While models are available for the analysis of frequency data in multiple classification designs (e.g., Sutcliff, 1957; Castellan, 1960), the basic assumption underlying their use is that all the factors must be independent (Winer, 1962). In the present investigation, only the first two factors, age, and sex, were independent. The second two factors, type of stimuli and type of task, were repeated measures. Consequently, the multifactor chi-square techniques could not be meaningfully used to handle the data of this study.

The chi-square test models selected were the two factor models (Downie and Heath, 1976; Siegel, 1956), employing both 2 x 2 contingency tables and 2 x 3 tables. In the 2 x 2 model, the factors were age x sex, age x stimuli and age x task. In the 2 x 3 model the factors were age x trials, age x type of matrix stimuli x trials, and stimuli x type of matrix.

The second type of data obtained conformed to the interval scale of measurement (Downie and Heath, 1976). This permitted the use of parametric techniques, for example, suitable models of the analysis of variance techniques. The following reasons may be advanced for using the parametric techniques:

1. Parametric techniques are more robust and powerful (Popham, 1967), and would more easily bring out significant differences than would the chi-square analyses.

2. By quantifying the data in the manner described, shades of differences would more easily be detectable than is possible through a system of forced dichotomization. For example, by simply categorizing a response as multi-dimensional (complex) as distinct from uni-dimensional (simple), information with regard to the kind of complex response, that is whether it is based on two or three salient attributes, is lost. With quantification, however, this information is retained and used in the statistical analysis. A complex response may be worth two points or three points, depending on the number of salient attributes utilized.

3. With appropriate parametric techniques, any interaction between variables could be examined.

4. Parametric techniques, especially the analysis of variance technique, have been used by other investigators in the field to handle similar data (e.g., Wei, Lavatelli, and Jones, 1971).

5. Theoretical justification for the use of parametric statistical techniques with essentially non-parametric data has been advanced by Popham (1967). He argues that if there is a logical and systematic basis for quantification, parametric techniques may be used without any distortion of results. He has empirically demonstrated that the differences in results between nonparametric and parametric techniques are too small to prevent the use of the latter. At the same time, the advantages to be gained in terms of power-efficiency and interactions, add weight to the argument that whenever feasible, parametric techniques are to be preferred to nonparametric techniques.

Having decided that parametric techniques could be used with the quantified data, the next step was the selection of a suitable model of the analysis of variance technique. The repeated measures anova model (Winer, 1962) was adopted as it was the best suited to the data to be analysed. Altogether three anova were executed, two of which were 2 x 2 x 2 analyses, one for free classification and one for matrix classification responses. Both were age x sex x type of stimuli factorial designs with repeated measures on the stimulus factor. The third was a four factor, 2 x 2 x 2 x 2, anova model, the factors being age x sex x stimuli x task, with repeated measures on the stimuli and task factors.

The four-factor model is the best that could be used since it incorporates an analysis of all the relevant variables. The two three-factor analyses may therefore appear to be redundant. However, they were necessary for purposes of comparing the non-parametric chi-square findings with those obtained through analysis of variance. As the free classification and matrix classification responses were analysed separately with the chi-square technique, the results could not be directly compared with those obtained through the use of the four-factor anova.

A detailed computation of one of each statistical test is presented in Appendix D.

5.4 SUMMARY

In this chapter, the methods employed in scoring the data have been described. The raw data obtained have been presented. The rationale for the choice of statistical techniques have also been discussed. In the next four chapters, the data are further analysed and the results discussed.

CHAPTER SIX

RESULTS AND DISCUSSION : FREE CLASSIFICATION BEHAVIOURAL RESPONSES

6.1 INTRODUCTION

The scoring of the free classification behavioural responses of the subjects has been described in detail in Chapter Five, and the data obtained have been presented. In this chapter, the free classification behavioural responses of the subjects will be statistically analysed and the results discussed.

Further, as already mentioned in the previous chapter, the free classification responses were analysed using both nonparametric and parametric techniques. These two types of analyses will be presented separately.

6.2 NONPARAMETRIC ANALYSES

As has been explained in Chapter Five, the nonparametric statistical technique used was the chi-square test. The contingency tables required for the analyses were obtained by counting the frequency of the kind of response being analysed, and separating the frequencies according to the independent variables being investigated. The analyses are presented below.

6.2.1 Sex relationships

Before proceeding to test the hypotheses listed in Chapter One, it was necessary to examine whether there were any sex relationships in the free classification behavioural responses, although no such relationships have been reported by previous investigators (Denney, 1972a; 1972b). If there were no significant sex relationships then the male and female subjects could be grouped for subsequent analyses.

Following on common practice, (e.g., Denney, 1972a), the free classification responses of subjects on Trial One were used in an age x sex chi-square test. The data for the contingency table were obtained by counting the number of males and females of each age group who succeeded in classifying the two types of stimuli. The criterion for "success" has already been described in Chapter Five. The results are presented below.

TABLE 13 : AN AGE X SEX CONTINGENCY TABLE OF SUCCESSFUL FREE CLASSIFICATION RESPONSES ON TRIAL ONE WITH 2-D STIMULI

SUBJECTS	SEX		TOTAL
	MALE	FEMALE	
9 Year Old	28	28	56
12 year Old	30	30	60
TOTAL	58	58	116

X^2 (1) = 0,007 p > 0,05

There was no significant relationship between sex and age in the free classification responses on the first trial using 2-D stimuli.

TABLE 14 : AN AGE X SEX CONTINGENCY TABLE OF SUCCESSFUL FREE CLASSIFICATION RESPONSES ON TRIAL ONE WITH 3-D STIMULI

SUBJECTS	SEX		TOTAL
	MALE	FEMALE	
9 Year Old	28	29	57
12 Year Old	30	30	60
TOTAL	58	59	117

X^2 (1) = 0,011 p > 0,05

There was no significant relationship between sex and age in the free classification responses on the first trial using 3-D stimuli.

As no significant relationship between sex and age was observed on the free classification responses on Trial One with both 2-D and 3-D stimuli, the sex variable was collapsed in all subsequent chi-square analyses. The next factor investigated was the relationship between age and the type of free classification behavioural response.

6.2.2 Age relationships

In investigating age relationships in free classification behavioural responses, the criterion of success as used in Tables 13 and 14 was considered unsuitable. This was because nearly all the subjects (93% of the 9 year olds and 100% of the 12 year olds) gave successful responses on the first trial with 2-D stimuli. The corresponding percentages with 3-D stimuli were 95% and 100% respectively. For this reason, it was decided to investigate age relationships in free classification behavioural responses by analysing the response complexity as defined by the dimensionality of the children's responses. In terms of the terminology used in Chapter Five, a simple response would be a uni-dimensional one while a complex response would be a multi-dimensional one.

The hypothesis tested was that there would be significant relationships between age and the complexity of the children's responses with both 2-D and 3-D stimuli. Two 2 x 2 (age x type of response) chi-squares were computed, one for 2-D and one for 3-D stimuli.

The response measure was the frequency of simple, uni-dimensional responses and complex, multi-dimensional responses given by the subjects of each age group on trial one. The results are presented below.

TABLE 15 : AN AGE X TYPE OF RESPONSE CONTINGENCY TABLE OF THE FREQUENCY OF UNI-DIMENSIONAL AND MULTI-DIMENSIONAL RESPONSES GIVEN BY THE SUBJECTS ON TRIAL ONE WITH 2-D STIMULI

SUBJECTS	TYPE OF RESPONSE		TOTAL
	UNIDIMENSIONAL	MULTIDIMENSIONAL	
9 Year Olds	37	19	56
12 Year Olds	22	38	60
TOTAL	59	57	116

X^2 (1) = 10,001 $p < 0,01$

TABLE 16 : AN AGE X TYPE OF RESPONSE CONTINGENCY TABLE OF THE FREQUENCY OF UNI-DIMENSIONAL AND MULTI-DIMENSIONAL RESPONSES GIVEN BY THE SUBJECTS ON TRIAL ONE WITH 3-D STIMULI

SUBJECTS	TYPE OF RESPONSE		TOTAL
	UNIDIMENSIONAL	MULTIDIMENSIONAL	
9 Year Olds	44	13	57
12 Year Olds	30	30	60
TOTAL	74	43	117

X^2 (1) = 9,289 $p < 0,01$

There was a significant relationship between age and the complexity of the subjects' free classification responses on trial one using 3-D stimuli. From the data in Table 16, it can be seen that the majority of the younger subjects gave simple, uni-dimensional responses while the majority of the older subjects gave complex, multi-dimensional responses.

From the data in Tables 15 and 16, it can be seen that significant relationships beyond the 0,01 level of significance were observed between age and complexity of responses on the first free classification trial using both 2-D and 3-D stimuli. It was decided to investigate whether this relationship persisted to the third free classification trial. Two 2 x 2 (age x type of response) chi-squares were computed for the data obtained on Trial Three, in the same way as was done above for Trial One. The results are presented below.

TABLE 17 : AN AGE X TYPE OF RESPONSE CONTINGENCY TABLE OF THE FREQUENCY OF UNI-DIMENSIONAL AND MULTI-DIMENSIONAL RESPONSES

SUBJECTS	TYPE OF RESPONSE		TOTAL
	UNIDIMENSIONAL	MULTIDIMENSIONAL	
9 Year Olds	31	17	48
12 Year Olds	30	26	56
TOTAL	61	43	104

X^2 (1) = 1,288   p > 0,05

There was no significant relationship between age and complexity of responses on the third free classification trial using 2-D stimuli.

TABLE 18 : AN AGE X TYPE OF RESPONSE CONTINGENCY TABLE OF THE UNI-DIMENSIONAL AND MULTI-DIMENSIONAL RESPONSES GIVEN BY SUBJECTS ON TRIAL THREE USING 2-D STIMULI

SUBJECTS	TYPE OF RESPONSE		TOTAL
	UNIDIMENSIONAL	MULTIDIMENSIONAL	
9 Year Olds	24	24	48
12 Year Olds	28	31	59
TOTAL	52	55	107

X^2 (1) = 0,068 p > 0,05

There was no significant relationship between age and complexity of responses on the third free classification trial using 3-D stimuli.

From the data in Tables 17 and 18, it can be seen that no significant relationships were observed between age and complexity of response on the third free classification trials using both 2-D and 3-D stimuli. From the data in Tables 15 and 16 it was observed that the same relationships were significant beyond the 0,01 level of significance on trial one. This was due mainly to the fact that many older subjects gave complex, multi-dimensional responses on trial one. When asked to reclassify, they fell back on simple uni-dimensional responses on trial three. At the same time, the younger subjects gave simple, uni-dimensional responses on trial one and improved their responses to multi-dimensional ones on trial three. On the third trial, therefore, the frequency of uni-dimensional and multi-dimensional responses were more or less the same among both the younger and the older subjects.

The next issue investigated was whether there were any age relationships in reclassification responses.

6.2.3 Reclassification responses

The hypothesis tested was that there would be a significant relationship between the number of younger and older subjects who successfully reclassified the stimuli. The information obtained from this investigation was expected to provide data on the ability versus preference issue in classification behaviour discussed in Chapter Three.

Age relationships in reclassification ability were investigated in the following manner:

1. Two 2 x 3 (age x trials) chi-squares were computed to investigate age relationships in the number of subjects who successfully reclassified the stimuli three times, irrespective of the dimensionality of the response. One chi-square analysis was computed for 2-D stimuli and one for 3-D stimuli.

2. Two 2 x 2 (age x trials) chi-squares were computed to investigate whether there were significant age relationships in the number complex, multi-dimensional responses given by the subjects on the first and last trials of the free classification task. One chi-square analysis was computed for 2-D stimuli and one for 3-D stimuli.

The results of these analyses are presented below:

TABLE 19 : NUMBER OF YOUNGER AND OLDER SUBJECTS SUCCESSFULLY RECLASSIFYING TWO-DIMENSIONAL STIMULI ACROSS TRIALS

SUBJECTS	TRIAL			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Younger	56	51	48	155
Older	60	58	56	174
TOTAL	116	109	104	329

X^2 (2) = 0,106 p > 0,05

There was no significant relationship between age and trials in the number of subjects who successfully reclassified the 2-D stimuli across Trials 1, 2, and 3.

TABLE 20 : NUMBER OF YOUNGER AND OLDER SUBJECTS SUCCESSFULLY RECLASSIFYING THREE-DIMENSIONAL STIMULI ACROSS TRIALS 1, 2, AND 3

SUBJECTS	TRIALS			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Younger Older	57 60	53 58	48 59	158 177
TOTAL	117	111	107	335

$X^2(2) = 0,358 \quad p > 0,05$

There was no significant relationship between age and trials in the number of subjects who successfully reclassified the 3-D stimuli across Trials 1, 2, and 3.

From the data in Tables 19 and 20, it can be seen that, when success is taken as the response measuer, that is a response based on similarity alone, irrespective of the dimensionality of the response, there is no significant relationship between age and trials on the free classification task. This was true of both 2-D and 3-D stimuli. Subjects of both age groups reclassified more or less equally well on the second and third trials.

It was next decided to investigate whether there were any significant relationships between age and trials in the complexity of the subjects' responses on the first and last trials of the free classification task. The contingency tables were drawn up by counting the number of complex, multi-dimensional responses given by the younger and older subjects on Trials 1 and 3. The results are presented in Table 21 (See page 105).

TABLE 21 : AN AGE X TRIAL CONTINGENCY TABLE OF MULTI-DIMENSIONAL RESPONSES ON THE FREE CLASSIFICATION TASKS USING 2-D STIMULI

SUBJECTS	TRIALS		TOTAL
	TRIAL 1	TRIAL 3	
Younger Older	19 38	17 26	36 64
TOTAL	57	43	100

$X^2(1) = 0,406 \quad p > 0,05$

There was no significant relationship between age and trials in the number of complex, multi-dimensional responses given by the subjects on Trials 1 and 3 of the free classification task using 2-D stimuli.

TABLE 22 : AN AGE X TRIAL CONTINGENCY TABLE OF MULTI-DIMENSIONAL RESPONSES ON THE FREE CLASSIFICATION TASKS USING 3-D STIMULI

SUBJECTS	TRIALS		TOTAL
	TRIAL 1	TRIAL 2	
Younger Older	13 30	24 31	37 61
TOTAL	43	55	98

$X^2(1) = 1,839 \quad p > 0,05$

There was no significant relationship between age and trials in the number of complex, multi-dimensional responses given by the subjects on Trials 1 and 3 of the free classification task using 3-D stimuli.

The results obtained thus far (Tables 19 to 22) indicate that age did not significantly affect reclassification responses, regardless of whether the response measure was simply success and failure or whether the complexity of the responses was taken into account.

The next issue examined with respect to reclassification behaviour was to determine whether subjects with each age group showed a change in the complexity of their responses across the three trials of the free classification task. Four 2 x 3 (type of response x trials) chi-squares were computed, one for each age group using 2-D stimuli, and one for each age group using 3-D stimuli. The contingency tables were drawn up by counting the number of simple uni-dimensional and complex multi-dimensional responses given by the subjects on each of the three trials with each set of stimuli. The results are presented below.

TABLE 23 : A TYPE OF RESPONSE X TRIALS CONTINGENCY TABLE OF THE YOUNGER SUBJECTS' RESPONSES USING 2-D STIMULI

TYPE OF RESPONSE	TRIALS			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Uni-dimensional	37	40	31	108
Multi-dimensional	19	11	17	47
TOTAL	56	51	48	155

$X^2(2) = 2{,}033 \quad p > 0{,}05$

There was no significant relationship between trials and the type of response made by the younger subjects using 2-D stimuli. The frequency of uni-dimensional and multi-dimensional responses were similar across the three trials.

TABLE 24 : A TYPE OF RESPONSE X TRIALS CONTINGENCY TABLE OF THE OLDER SUBJECTS' RESPONSES USING 2-D STIMULI

TYPE OF RESPONSE	TRIALS			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Uni-dimensional	22	30	30	82
Multi-dimensional	38	28	26	92
TOTAL	60	58	56	174

$X^2(2) = 3,80 \quad p > 0,05$

There was no significant relationship between trials and the type of response made by the older subjects using 2-D stimuli. The frequency of uni-dimensional and multi-dimensional response were similar across the three trials.

TABLE 25 : A TYPE OF RESPONSE X TRIALS CONTINGENCY TABLE OF THE YOUNGER SUBJECTS' RESPONSES USING 3-D STIMULI

TYPE OF RESPONSE	TRIALS			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Uni-dimensional	44	32	24	100
Multi-dimensional	13	21	24	58
TOTAL	57	53	48	158

$X^2(2) = 8,354 \quad p < 0,05$

There was a significant relationship between trials and the type of responses given by the younger subjects using 3-D stimuli. From the data in Table 25 above, it can be seen that there was a progressive decrease in the frequency of uni-dimensional responses and a progressive increase in the frequency of multi-dimensional responses across Trials 1 to 3.

TABLE 26 : A TYPE OF RESPONSE X TRIALS CONTINGENCY TABLE OF THE OLDER SUBJECTS' RESPONSES USING 3-D STIMULI

TYPE OF RESPONSE	TRIALS			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Uni-dimensional	30	32	28	90
Multi-dimensional	30	26	21	87
TOTAL	60	58	59	177

$X^2(2) = 1,097 \quad p > 0,05$

There was no significant relationship between trials and the type of response made by the older subjects using 3-D stimuli. The frequency of uni-dimensional and multi-dimensional responses were the same across the three trials.

The results obtained from the data in Tables 23 to 26 indicate that the older subjects showed no change in the complexity of their responses across the three free classification trials using both 2-D and 3-D stimuli. This was also true for the younger subjects using 2-D stimuli. However, the younger subjects using 3-D stimuli, showed a significant shift towards more complex, multi-dimensional responses. With each successive trial, they showed an increase in the frequency of multi-dimensional responses given.

The relationships involving the type of stimuli on free classification responses were investigated next.

6.2.4 Stimulus relationships in free classification responses

In this section, the issue investigated was whether the subjects found the 2-D and the 3-D stimuli of equal difficulty or whether they found one set easier to work with than the other. It was assumed that the easier stimuli would tend to elicit more complex, multi-dimensional responses than would the more difficult stimuli. Therefore, the number of multi-dimensionsional responses given by the subjects of each age group on each free classification trial was taken as the response measure.

The hypothesis tested was that there would be a significant relationship between age and type of stimuli as measured by the number of multi-dimensional responses given on the free classification trials. Three 2 x 2 (age x type of stimuli) chi-squares were computed, one for each free classification trial. The contingency tables reflect the frequency of multi-dimensional responses given by the younger and older children, using 2-D and 3-D stimuli. The results are presented below.

TABLE 27 : AN AGE X TYPE OF STIMULI CONTINGENCY TABLE OF MULTI-DIMENSIONAL RESPONSES GIVEN BY SUBJECTS ON TRIAL 1 OF THE FREE CLASSIFICATION TASK

SUBJECTS	STIMULI		TOTAL
	2-D	3-D	
Younger	19	13	32
Older	38	30	68
TOTAL	57	43	100

$X^2(1) = 0{,}110 \quad p > 0{,}05$

There was no significant relationship between age and type of stimuli in the number of multi-dimensional responses biven by the subjects on Trial 1 of the free classification task.

TABLE 28 : AN AGE X TYPE OF STIMULI CONTINGENCY TABLE OF MULTI-DIMENSIONAL RESPONSES GIVEN BY SUBJECTS ON TRIAL 2 OF THE FREE CLASSIFICATION TASK

SUBJECTS	STIMULI		TOTAL
	2-D	3-D	
Younger	11	21	32
Older	28	26	54
TOTAL	30	47	86

$X^2(1) = 2,468 \quad p > 0,05$

There was no significant relationship between age and type of stimuli in the number of multi-dimensional responses given by the subjects on Trial 2 of the free classification task.

TABLE 29 : AN AGE X TYPE OF STIMULI CONTINGENCY TABLE OF MULTI-DIMENSIONAL RESPONSES GIVEN BY SUBJECTS ON TRIAL 3 OF THE FREE CLASSIFICATION TASK

SUBJECTS	STIMULI		TOTAL
	2-D	3-D	
Younger	17	24	41
Older	26	31	57
TOTAL	43	55	98

$X^2(1) = 0,165 \quad p > 0,05$

There was no significant relationship between age and type of stimuli in the number of multi-dimensional responses given by the subjects on Trial 3 of the free classification task.

The results obtained from the data in Tables 27 to 29 show that there is no relationship between the type of stimuli and age of subjects in the frequency of multi-dimensional responses given by the subjects on any of the three trials of the free classification task.

6.2.5 Summary of Results : Nonparametric analyses of free classification responses

From the preceeding discussion, it will be noted that a total of 17 chi-squares were computed. These are tabulated in summary from below.

TABLE 30 : SUMMARY TABLE OF THE CHI-SQUARES ANALYSES

TABLE	VARIABLES INVESTIGATED	X^2	DF	p
13	Sex x Age, Trial 1, 2-D Stimuli	0,007	1	> 0,05
14	Sex x Age, Trial 1, 3-D Stimuli	0,011	1	> 0,05
15	Age x Type of Response, Trial 1, 2-D Stimuli	10,011	1	< 0,01**
16	Age x Type of Response, Trial 1, 3-D Stimuli	9,289	1	< 0,01*
17	Age x Type of Response, Trial 3, 2-D Stimuli	1,288	1	> 0,05
18	Age x Type of Response, Trial 3, 3-D Stimuli	0,068	1	> 0,05
19	Age x Trials, "Successful" Response, 2-D Stimuli	0,106	2	> 0,05
20	Age x Trials, "Successful" Response, 3-D Stimuli	0,358	2	> 0,05
21	Age x Trials, Multi-dimensional Responses, 2-D Stimuli	0,406	1	> 0,05
22	Age x Trials, Multi-dimensional Responses, 3-D Stimuli	1,839	1	> 0,05
23	Type of Response x Trials, Younger Subjects, 2-D Stimuli	2,033	2	> 0,05
24	Type of Response x Trials, Older Subjects, 2-D Stimuli	3,800	2	> 0,05
25	Type of Response x Trials, Younger Subjects, 2-D Stimuli	8,354	2	< 0,05*
26	Type of Response x Trials, Older Subjects, 3-D Stimuli	1,097	2	> 0,05
27	Type of Stimuli x Age, Trial 1	0,110	1	> 0,05
28	Type of Stimuli x Age, Trial 2	2,468	1	> 0,05
29	Type of Stimuli x Age, Trial 3	0,165	1	> 0,05

** Significant at 0,01 level
 * Significant at 0,05 level

From the above Table (Table 30) it can be seen that the following results were obtained:

1. Significant relationships between age and type of response were obtained on the first trial of the free classification task using 2-D and 3-D stimuli. This relationship was not observed on the third trial.

2. A significant relationship between type of response and trials was obtained among the younger subjects using 3-D stimuli. There was a progressive shift from uni-dimensional to multi-dimensional responses across the three trials. This relationship was not observed among the younger subjects using 2-D stimuli, and among the older subjects using 2-D and 3-D stimuli.

3. No significant relationships were obtained between sex and age in the number of subjects who successfully free classified both 2-D and 3-D stimuli on the first trial.

4. The type of stimuli used had no significant effect on the free classification responses of the subjects.

The results are discussed in the section that follows.

6.2.6 Discussion of results : free classification behavioural responses

In discussing the results obtained by nonparametric analyses of free classification behavioural responses, it was considered convenient to follow the same headings as was used to present the results.

6.2.6.1 Sex relationships

From Tables 13 and 14, it can be seen that no significant relationships were observed between sex and free classification responses on both 2-D and 3-D stimuli. Lack of significant relationships between sex and free classification responses have been reported by other investigators as well, e.g., Wei, Latavelli and Jones (1971) and Denney (1972a). It will be remembered that the stimuli employed were geometric forms and shapes, and should, therefore, have favoured the males in terms of conventional sex stereotyping in which boys are generally assumed to be better on tasks involving perception and manipulation of stimuli from a mathematical domain (Maccoby and Jacklin, 1974). It seems that at the young age this is not so.

Since the sex variable was found to be non-significant, it was collapsed in all subsequent analyses.

6.2.6.2 Developmental changes

Significant age relationships were observed in the number of multi-dimensional free classification responses given by the subjects on the first trial on both 2-D stimuli (Table 21) and 3-D stimuli (Table 22). In both instances, the younger subjects gave more simple, uni-dimensional responses while the older subjects gave more complex, multi-dimensional responses. These results support the hypothesis that there would be significant age difference in free classification responses.

The above results support the findings of Kofsky (1966), Wei, Lavatelli and Jones (1971) and Denney (1972a). Denney (1972b), however, found no difference in uni-dimensional and multi-dimensional responses between subjects aged 2, 3, and 4 years, using the same criteria for complexity as was used in the present investigation. This was perhaps due to the characteristics of her subjects who were too young and were probably still in the pre-operational period and hence could not decentrate. Further, the ages of the groups were too close together to reveal any possible age differences.

When age relationships were investigated by analysing the responses of subjects on the third trial of the free classification task, no significant relationships were observed (Tables 17 and 18). By looking at the Summary Table (p. 111) and comparing Tables 15 and 17, and Tables 16 and 18, it will be noted that the older subjects gave more complex, multi-dimensional responses on Trial 1 than they did on Trial 3. At the same time, the younger subjects gave more multi-dimensional responses on Trial 3 than they did on Trial 1. This probably neutralised the superiority of the older subjects' responses recorded on Trial 1 by the time Trial 3 was reached. The reason for this reversal could be that the older subjects gave complex multi-dimensional responses on the initial trial. On being asked to reclassify, they probably suspected trickery of some sort and fell back on simple uni-dimensional responses. On the other hand, fewer of the younger subjects started with multi-dimensional responses, thus unintentionally leaving room for improvement in the quality of their responses on successive trials.

In conclusion, it can be said that when the initial responses of subjects are considered, older subjects tend to give a significantly greater number of complex, multi-dimensional responses than do younger subjects.

6.2.6.3 Reclassification responses

No significant age relationships were observed among the subjects who successfully reclassified the 2-D stimuli (Table 19) and 3-D stimuli (Table 20) across three trials. The hypothesis that there would be age difference in reclassification behaviour must, therefore, be rejected. It seems that by age 9 years, the child's ability is adequately tapped by a single trial and additional trials reveal no further information in this regard. Cole and Scribner (1969) report a paucity of data on reclassification ability. Such apparent lack of research in the area suggest that perhaps nothing new is added by examining reclassification trials, especially among older children.

The question that arises is whether reclassification trials are necessary. It would appear that they are, especially in order to provide data on the preference versus ability issue. Without reclassification trials, it would not be possible to discover whether subjects could improve on their initial responses or not. Improvement on subsequent trials would indicate that the initial response was based on preference.

The preference versus ability issue was examined in two ways. Firstly, first and third trial responses were examined to see if there were any significant age relationships. The first and third trials were chosen as the observed differences appeared to be the greatest between them. The response measure was the frequency of multi-dimensional responses given by subjects. The results were not significant for both 2-D and 3-D stimuli (Tables 21 and 22). However, some individuals did improve on their initial responses, indicating that for them at least, the first response was a matter of preference.

The second way in which the preference versus ability issue was examined was by analysing the complexity of responses across trials within each group of subjects with each type of stimuli. Only one of the four analyses was statistically significant, namely the younger subjects using 2-D stimuli showed a progressive increase in the number of multi-dimensional responses across the three trials (Table 25). Although the other three analyses were not statistically significant, the chi-square values were relatively high ($X^2(2) = 2{,}033$, Table 22, $X^2(2) = 3{,}80$, Table 24, and $X^2(2) = 1{,}097$, Table 26). This suggests that although the results were not significant individuals within the groups were showing changes in the type of response across the three trials. As has been mentioned earlier, the younger subjects showed a tendency to improve from uni-dimensional to multi-dimensional responses. The older subjects appeared to retrogress from multi-dimensional to uni-dimensional responses. The fact that some subjects did improve their responses from uni-dimensional to multi-dimensional ones does suggest that the initial responses were a matter of preference. Given the opportunity of reclassifying, they did manifest the ability to give multi-dimensional responses. Perhaps, employing a larger sample or using a younger age group may reveal statistically significant results in this direction. This can only be determined by including reclassification trials.

6.2.6.4 Stimulus relationships

No significant differences in the performance of the younger and older subjects in 2-D and 3-D stimuli were observed on all three trials of the free classification task (Tables 27, 28, and 29). The hypothesis that there would be a significant difference between 2-D and 3-D stimuli is, therefore, rejected.

It would appear that both the younger and older subjects find the 2-D and 3-D stimuli equally familiar. Also, since the younger subjects have already begun to successfully classify and reclassify (Tables 19, 20) the stimulus variable may no longer be an important issue. Thirdly, the two sets of stimuli were from the same domain (geometric shapes and forms) and both sets may have been equally difficult or familiar. Fourthly, the scoring technique of regarding responses based on two or three attributes of the stimuli as multi-dimensional without differentiating between the two, may also have contributed towards the kind of results obtained. For these reasons, it will not be meaningful to compare these results with those of previous investigators such as Irwin and McLaughlin (1970) or Deregowski and Serpell (1971), whose familiar stimuli were very different from their unfamiliar stimuli. These investigators have shown that the familiar stimuli produce a higher rate of success on classification and reclassification than do the unfamiliar stimuli. The concept of familiarity within this context certainly needs further empirical investigation, if the findings are to have any external validity.

Since the age of the subjects and the nature of the stimuli varied in the studies mentioned and this study, the apparent inconsistency in the findings may have another possible explanation. There could be an age x stimuli interaction. This unfortunately cannot be determined through the chi-squares technique.

In concluding the discussion on nonparametric analyses of free classification responses, the major findings may be summarized. Significant age differences were noted in the number of subjects successfully free classifying both 2-D and 3-D stimuli on the first trial. The younger subjects using 3-D stimuli showed significant improvement in the number of complex responses given on successive trials. All the other analyses yielded results which were not significant.

6.3 PARAMETRIC ANALYSES

The free classification responses were quantified and analysed through the analysis of variance technique. The rationale and the procedure for quantification have already been described in Chapter Five.

The data obtained was subjected to a 2 x 2 x 2 (Sex x Age x Type of Stimuli) analysis of variance with repeated measures on the stimulus factor (Winer, 1962). The results are presented below. (See page 118)

TABLE 31 : SUMMARY TABLE OF A SEX X AGE X TYPE OF STIMULUS ANALYSES OF THE SCORES OF 120 SUBJECTS ON THE FREE CLASSIFICATION TASK

SOURCE OF VARIATION	SS	DF	MS	F	P
Between Subjects	360,733	119			
Sex	1,667	1	1,667		
Age	88,816	1	88,816	38,184	<0,01
Sex x Age	,418	1	,418		
Subjects x Within Group Error	269,833	116	2,326		
Within Subjects	109,000				
Stimuli (2-D vs 3-D)	,067	1	,067		
Sex x Stimuli	,068	1	,068		
Age x Stimuli	,818	1	,818		
Age x Sex x Stimuli	,014	1	,014		
Stimuli x Subjects Within Group Error	108,034	116	,931		

From Table 31, it can be seen that the only variable found to be significant was age ($F(1,116) = 38{,}184$, $p < 0{,}01$). None of the other variables was significant nor were any of the interactions.

In order to explain the significant F ratio for the age factor, it is necessary to look at the mean scores obtained by the younger and older subjects. This is tabled below. (See

TABLE 32 : MEAN SCORES OF YOUNGER (N = 60) AND OLDER (N = 60) SUBJECTS ON FREE CLASSIFICATION TASK

	YOUNGER SUBJECTS	OLDER SUBJECTS
Mean Score	5,72	7,15

From Table 32 above it can be seen that the older subjects obtained a higher mean score on the free classification task than did the younger subjects. This indicates that the older subjects tended to give more complex, multi-dimensional responses thus scoring higher, than did the younger subjects. This supports Piaget's (Inhelder and Piaget, 1964) contention that hierarchical classification is achieved by approximately 11 years of age.

6.3.1 Discussion of results

As has been stated above (Table 32), the older subjects give more multi-dimensional responses than do the younger subjects. This finding confirms the hypothesis that there would be significant age differences in free classification. This hypothesis has now been confirmed through the chi-square test and the analysis of variance. The results also support Popham's (1967) conclusion that parametric techniques applied to this type of nonparametric data yield results which do not differ very much from those obtained by nonparametric techniques. Information is not distorted by using parametric techniques.

The absence of significant sex and stimulus differences have also been corroborated by both the chi-square tests and the analyses of variance.

6.4 SUMMARY : FREE CLASSIFICATION RESPONSES

In summary, it may be said that age was the only significant variable affecting the free classification behavioural responses of the subjects. The sex and stimulus variables were found to be not significant. This was so using both parametric and nonparametric techniques.

A possible reason for the absence of a significant stimulus effect may be the fact that by age 9, the younger subjects are already showing 93% success rate on 2-D stimuli and 95% success on the 3-D stimuli on the free classification task (See Section 6.2.2 p. 99). Even the younger subjects were too old and perhaps therefore equally familiar with both sets of stimuli.

In the next chapter, the effect of the same variables (age, sex, and type of stimuli) on matrix classification responses will be investigated.

CHAPTER SEVEN

RESULTS AND DISCUSSION : MATRIX CLASSIFICATION BEHAVIOURAL RESPONSES

7.1 INTRODUCTION

The matrix classification responses of the subjects were analysed through both nonparametric and parametric techniques, as was the case with the free classification responses. Chi-square analyses used to investigate the effect of sex, age, and type of stimuli on the matrix tasks. In addition, the relative difficulty of each of the matrix tasks was examined.

The response measure used in the analyses was slightly different from that used to analyse the free classification responses. Since the matrix task was a structured one, requiring a specific response, subject responses were scored correct or incorrect. The details of the scoring procedure have already been presented in Chapter Five. The analyses are presented below.

7.2 NONPARAMETRIC ANALYSES

Chi-square tests were used to analyse the effect of sex, age, and type of stimuli on the matrix classification responses. The sex variable was examined first.

7.2.1 Sex relationships

Sex differences in matrix classification responses were investigated by pooling together all the correct responses given by the subjects across the three trials for each set of stimuli (2-D and 3-D). As indicated previously (Chapter Five) there were three matrix tasks with each set of stimuli, and each task was presented with three, four, or five prompts, depending upon the subjects' responses. The contingency tables below (Tables 33 and 34) reflect the frequency of correct responses given by the subjects on the three trials combined disregarding whether success was achieved after three, four, or five prompts. Each subject had to complete six matrices, three with 2-D stimuli and three with 3-D stimuli. There were 30 subjects in each cell, and the maximum response frequency could thus be 90 per cell for each type of stimuli.

TABLE 33 : AN AGE X SEX CONTINGENCY TABLE OF CORRECT RESPONSES ON THE THREE MATRIX TASKS USING 2-D STIMULI

AGE GROUP	SEX		TOTAL
	MALES	FEMALES	
Younger	56	49	105
Older	78	76	154
TOTAL	134	125	259

$X^2(1) = 0{,}180 \quad p > 0{,}05$

There was no significant relationship between age and sex in the number of correct responses given by the subjects on the three matrix tasks using 2-D stimuli.

TABLE 34 : AN AGE X SEX CONTINGENCY TABLE OF CORRECT RESPONSES ON THE THREE MATRIX TASKS USING 3-D STIMULI

AGE GROUP	SEX		TOTAL
	MALES	FEMALES	
Younger	55	52	107
Older	82	86	168
TOTAL	137	138	275

$X^2(1) = 0{,}176 \quad p > 0{,}05$

There was no significant relationship between age and sex in the number of correct responses given by the subjects on the three matrix tasks using 3-D stimuli.

Since no significant relationship between sex and age was observed on the matrix responses of subjects with both 2-D and 3-D stimuli, it was decided to collapse the sex variable by pooling the scores of male and female subjects for all subsequent analyses.

7.2.2 Age relationships

To investigate age relationships, the response measure used was the frequency of correct and incorrect responses given by the subjects on the three matrix tasks with each type of stimuli.

Firstly, it was decided to investigate if there were any significant age relationships among the subjects who responded correctly with the minimum of three prompts. This is somewhat analagous to the initial free classification trial. The results are presented below. With the sex variable collapsed, the maximum response frequency in each cell could be 180 (60 subjects, each given three matrix trials).

TABLE 35 : FREQUENCY OF CORRECT/INCORRECT RESPONSES GIVEN BY SUBJECTS ON THE THREE MATRIX TASKS AFTER THREE PROMPTS USING 2-D STIMULI

SUBJECTS	RESPONSES		TOTAL
	CORRECT	INCORRECT	
Younger	65	115	180
Older	104	76	180
TOTAL	169	191	360

$X^2(1) = 16,961 \quad p < 0,01$

There was a significant relationship between age and the frequency of correct/incorrect responses given by the subjects on the three matrix tasks with three prompts using 2-D stimuli. From Table 35, it can be seen that the older subjects gave significantly more correct responses than did the younger subjects.

TABLE 36 : FREQUENCY OF CORRECT/INCORRECT RESPONSES GIVEN BY SUBJECTS ON THE THREE MATRIX TASKS AFTER THREE PROMPTS USING 3-D STIMULI

SUBJECTS	RESPONSE		TOTAL
	CORRECT	INCORRECT	
Younger	63	117	180
Older	123	57	180
TOTAL	186	174	360

$X^2(1) = 40,04 \quad p < 0,01$

There was a significant relationship between age and the frequency of correct/incorrect responses given by the subjects on the three matrix tasks after three prompts using 3-D stimuli. The older subjects succeeded significantly more frequently than did the younger subjects.

The above results indicate that with the minimum of three prompts the older subjects solve more of the matrix problems than do the younger subjects. This applies to both 2-D (Table 35) and 3-D (Table 36) stimuli.

It was next decided to investigate if the age relationship persisted if the maximum of five prompts were provided. The question posed was, would the additional assistance tend to change the age relationships reported? The contingency tables reflect the frequency of correct and incorrect responses given by the subjects on the three matrix tasks after five prompts. The frequency in each cell represents a cumulative total after three, four, and five prompts. The results are presented below. The maximum response frequency in each cell could be 180 (60 subjects, each given three matrix trials).

TABLE 37 : FREQUENCY OF CORRECT/INCORRECT RESPONSES GIVEN BY SUBJECTS ON THE THREE MATRIX TASKS WITH THREE TO FIVE PROMPTS USING 2-D STIMULI

SUBJECTS	RESPONSE		TOTAL
	CORRECT	INCORRECT	
Younger	105	75	180
Older	154	26	180
TOTAL	259	101	360

$X^2(1) = 33{,}038 \quad p < 0{,}01$

There was a significant relationship between age and the correctness of the subjects' responses on the three matrix tasks after three to five prompts using 2-D stimuli. The older subjects finally succeeded more frequently than did the younger subjects.

TABLE 38 : FREQUENCY OF CORRECT/INCORRECT RESPONSES GIVEN BY SUBJECTS ON THE THREE MATRIX TASKS WITH THREE TO FIVE PROMPTS USING 3-D STIMULI

SUBJECTS	RESPONSE		TOTAL
	CORRECT	INCORRECT	
Younger	107	73	180
Older	168	12	180
TOTAL	275	85	360

$X^2(1) = 57{,}302 \quad p < 0{,}01$

There was a significant relationship between age and the correctness of the subjects' responses on the three matrix tasks after three to five prompts using 3-D stimuli. The older subjects finally succeeded more frequently than did the younger subjects.

From the data on Tables 35 to 38 it can be seen that there was a significant relationship between age and the subjects' matrix responses. This was true of both 2-D (Tables 35 and 37) and 3-D (Tables 36 and 38) stimuli. Also the number of prompts provided did not appear to close the age gap. Older subjects tended to succeed more frequently than did younger subjects after three prompts or after four, and five prompts.

7.2.3 Stimulus relationships

The relationship between 2-D and 3-D stimuli on the matrix classification responses of the subjects was next investigated. The data for the contingency tables were obtained by counting the frequency of correct and incorrect responses given by the subjects of each age group after the maximum of five prompts. Two 2 x 2 (Type of Stimuli x Response) chi-squares, one for each age group, were computed. The results are presented below. The maximum response frequency in each cell could be 180. (Table 39)

TABLE 39 : FREQUENCY OF CORRECT AND INCORRECT RESPONSE GIVEN BY THE YOUNGER SUBJECTS ON THE THREE MATRIX TASKS USING 2-D AND 3-D STIMULI

STIMULI	RESPONSE		TOTAL
	CORRECT	INCORRECT	
2-D 3-D	105 107	75 73	180 180
TOTAL	212	148	360

$X^2(1) = 0,046 \quad p > 0,05$

There was no significant relationship between the type of stimuli and the number of correct/incorrect responses given by the younger subjects on the three matrix tasks after five prompts. The frequency of correct responses was about the same with 2-D and 3-D stimuli.

TABLE 40 : FREQUENCY OF CORRECT/INCORRECT RESPONSE GIVEN BY OLDER SUBJECTS ON THE THREE MATRIX TASKS USING 2-D AND 3-D STIMULI

STIMULI	RESPONSES		TOTAL
	CORRECT	INCORRECT	
2-D 3-D	154 168	26 12	180 180
TOTAL	322	38	360

$X^2(1) = 5,764 \quad p < 0,05$

There was a significant relationship between the type of stimuli and the number of correct/incorrect responses given by the older subjects on the three matrix tasks after five prompts. The older subjects gave correct responses more frequently with 3-D stimuli than they did with 2-D stimuli.

From the data on Tables 39 and 40, it can be seen that there was no significant relationship between the type of stimuli and the matrix responses of the younger children but the relationship was significant among the older subjects. The older subjects succeeded more frequently with 3-D stimuli than with 2-D stimuli. The responses of the younger subjects (Table 39) reflects the same trend, although the difference is not large enough to yield a statistically significant result.

7.2.4 Relative difficulty of the three tasks

The relative difficulty of each of the matrix tasks, namely, the colour x shape, colour x size and shape x size matrices, was examined. Firstly, the stimuli used had two distinct features comprising two discrete attributes (colour and shape) and one continuous or relational attribute (size). Therefore only one of the three matrix tasks was made up of discrete attributes in both directions (colour x shape). The other two matrix tasks were made up of a discrete feature in one direction and a relational feature in the other (colour x size, and shape x size). It was decided to examine whether this type of combination of discrete and relational stimulus attributes affected the responses of the subjects.

In addition, the three matrix tasks were presented in a fixed order. For all the subjects the colour x shape matrix was given first, the colour x size second and the shape x size last. It was quite possible that transfer effects could have taken place. This had to be investigated.

The level of difficulty of the three matrix tasks was examined separately for responses measured after three prompts and after five prompts. Altogether, four 2 x 3 (Age x type of matrix) chi-squares were computed, two for each type of stimuli, of which one was for three prompts and one for five prompts. The data for the contingency table were the number of correct responses given by the subjects on each matrix task. The results are presented below. (Table 41). The maximum response frequency in each cell was 60 (60 subjects in each group, after sex collapsed).

TABLE 41 : AN AGE X TYPE OF MATRIX CONTINGENCY TABLE OF CORRECT RESPONSES GIVEN BY SUBJECTS ON EACH MATRIX TASK AFTER THREE PROMPTS USING 2-D STIMULI

SUBJECTS	TYPE OF MATRIX			TOTAL
	COLOUR x SHAPE	COLOUR x SIZE	COLOUR x SHAPE	
Younger	13	27	25	65
Older	24	48	32	108
TOTAL	37	75	57	169

$X^2(2) = 0{,}950 \quad p > 0{,}05$

There was no significant relationship between age and the type of matrix that was correctly solved by the subjects after three prompts using 2-D stimuli.

TABLE 42 : AN AGE X TYPE OF MATRIX CONTINGENCY TABLE OF CORRECT RESPONSES GIVEN BY SUBJECTS ON EACH MATRIX TASK AFTER THREE PROMPTS USING 3-D STIMULI

SUBJECTS	TYPE OF MATRIX			TOTAL
	COLOUR x SHAPE	COLOUR x SIZE	SHAPE x SIZE	
Younger	14	23	26	63
Older	30	51	42	123
TOTAL	44	74	68	186

$X^2(2) = 0{,}918 \quad p > 0{,}05$

There was no significant relationship between age and the type of matrix that was correctly solved by the subjects after three prompts using 3-D stimuli.

TABLE 43 : AN AGE X TYPE OF MATRIX CONTINGENCY TABLE OF CORRECT RESPONSES GIVEN BY SUBJECTS ON EACH MATRIX TASK AFTER FIVE PROMPTS USING 2-D STIMULI

SUBJECTS	TYPE OF MATRIX			TOTAL
	COLOUR x SHAPE	COLOUR x SIZE	SHAPE x SIZE	
Younger	32	38	35	105
Older	45	56	53	154
TOTAL	77	94	88	259

$X^2(2) = 0,045 \quad p > 0,05$

There was no significant relationship between age and the type of matrix that was correctly solved by the subjects after five prompts using 2-D stimuli.

TABLE 44 : AN AGE X TYPE OF MATRIX CONTINGENCY TABLE OF CORRECT RESPONSES GIVEN BY SUBJECTS ON EACH MATRIX TASKS AFTER FIVE PROMPTS USING 3-D STIMULI

SUBJECTS	TYPE OF RESPONSE			TOTAL
	COLOUR x SHAPE	COLOUR x SIZE	SHAPE x SIZE	
Younger	29	41	37	107
Older	50	60	58	168
TOTAL	79	101	95	275

$X^2(2) = 0,282 \quad p > 0,05$

There was no significant relationship between age and the type of matrix that was correctly solved by the subjects after five prompts, using 3-D stimuli.

The results indicate that subjects found each type of matrix of equal difficulty, regardless of whether they worked with 2-D stimuli (Tables 41 and 43) or with 3-D stimuli (Tables 42 and 44). This was true whether the responses were measured after 3 prompts (Tables 41 and 42) or after five prompts (Tables 43 and 44). The matrix composed of discrete attributes in both directions was solved as frequently as the matrices composed of one discrete and one relational attribute. As there were no differences among the type of matrix correctly solved, and since the three matrices were presented in a fixed order, it can be inferred that there was no significant order effect on the frequency of success on the matrix tasks.

7.2.5 Summary of Results : Nonparametric analyses of matrix responses

The nonparametric chi-square analyses were used to investigate the effects of the sex, age, and stimulus variables on the subjects' responses on the matrix classification tasks. In addition, the relative difficulty of the three matrix tasks were investigated. The results are summarised in the table below. (Table 45, p. 132).

TABLE 45 : SUMMARY TABLE OF CHI-SQUARES ANALYSES : MATRIX RESPONSES

TABLE	VARIABLES INVESTIGATED	X^2	df	p
33	Sex x Age, 2-D Stimuli	0,180	1	>0,05
34	Sex x Age, 3-D Stimuli	0,176	1	>0,05
35	Age x Success, 3 Prompts 2-D Stimuli	16,961	1	<0,01**
36	Age x Success, 3 Prompts 3-D Stimuli	40,040	1	<0,01**
37	Age x Success, 5 Prompts, 2-D Stimuli	33,038	1	<0,01**
38	Age x Success, 5 Prompts, 3-D Stimuli	57,302	1	<0,01**
39	Stimuli x Success, Younger Subjects	0,046	1	>0,05
40	Stimuli x Success, Older Subjects	5,764	1	<0,05*
41	Type of Matrix x Age, 3 Prompts, 2-D Stimuli	0,950	2	>0,05
42	Type of Matrix x Age, 3 Prompts, 3-D Stimuli	0,918	2	>0,05
43	Type of Matrix x Age, 5 Prompts, 2-D Stimuli	0,045	2	>0,05
44	Type of Matrix x Age, 5 Prompts, 3-D Stimuli	0,282	2	>0,05

** = Significant at 0,01 level
* = Significant at 0,01 level

From the Table above, it can be seen that the only variable that consistently had a significant relationships with the matrix classification responses of the subjects, was age. Age relationships were significant beyond the 99% confidence level in each of the following instances:

1. Number of successful responses given by subjects after three prompts, using 2-D stimuli (Table 35).

2. Number of successful responses given by the subjects after three prompts, using 3-D stimuli (Table 36).

3. Number of successful responses given by the subjects after five prompts, using 3-D stimuli (Table 38).

In each of the four instance, the older subjects achieved a higher rate of success than did the younger subjects.

The stimulus variable had a significant effect on the success of the older subjects, who did better on the 3-D stimuli than on the 2-D stimuli (Table 39). This difference was not observed among the younger subjects (Table 40).

All the other analyses yielded results that were not statistically significant.

The results are discussed below.

7.2.6 Discussion of Results : Nonparametric analyses of matrix classification responses

For ease of reference the results are discussed in the same order in which they were presented. It also makes reference to the discussion of free classification results (Chapter Six) easier, as the same order was followed there.

7.2.6.1 Sex relationships

There was no significant relationship between sex and the subjects' responses on the matrix tasks, using 2-D (Table 33) and 3-D (Table 34) stimuli. Although somewhat contrary to the conventional sex stereotype (See Chapter Six), these results were expected as there is no evidence for sex differences in the literature on matrix classification (e.g., MacKay, Fraser, and Ross, 1970).

The sex variable was collapsed and the responses of males and females were pooled in all subsequent analyses.

7.2.6.2 Age relationships

The hypothesis tested was that there would be significant differences between the younger and older subjects in the frequency of successful responses given on the matrix tasks, using 2-D and 3-D stimuli.

The results obtained confirm the above hypothesis.

Significant age relationships in the number of successful responses given on the matrix tasks after three prompts were observed on both 2-D (Table 35) and 3-D (Table 36) stimuli. Similar results were obtained when success on the matrix task was measured after five prompts on both 2-D (Table 37) and 3-D (Table 38) stimuli. In each instance the older subjects obtained a higher rate of success than did the younger subjects.

The above results indicate that regardless of whether the matrix task is performed with 2-D or 3-D stimuli, or whether success is measured after three or five prompts, the older subjects succeed more often than do the younger subjects.

Age differences in matrix classification behaviour have been reported consistently by previous investigators (MacKay, Fraser and Ross, 1970; Wei, Lavatelli and Jones, 1971). Although there are variations in procedure, age of subjects and choice of stimuli, the general finding is that matrix classification behaviour improves as age increases. The results of the present investigation also support the findings.

Flavell and Wohwill (1969) (as reported by Triandis, 1980) proposed that the probability that a child will solve a given problem or correctly complete a task, is a product of two probabilities:

(1) the probability that the child has the competence to do the task, and

(2) the probability that the task will elicit the skills of the particular child.

The second probability is raised to the power 1 - k, where k varies with age, so that for older children it tends to be equal to 1,00. The second probability, therefore, has no effect when the child is old, but has a maximum effect when the child is young. For the very young, the first probability is close to zero and there is no performance. For older children, both probabilities are high so that the children are able to bring their competence to bear on the problem regardless of the situation or the task. For children in between these extremes, the first probability is some quantity greater than zero, so that performance is very much dependent on the task situation. Dasen (1977) added a third probability to this formulation, which is multiplied by the other two probabilities. This third probability reflects the likelihood, for any given task, that the operation will in fact be called to play in a given cultural milieu. The third probability is raised to the power k, so its effect can increase with age.

The above formulation emphasizes that performance is a function of an attribute of a person, an attribute of the situation, and an attribute of the culture. The relative importance of these three attributes change with the child's age.

The results of the present investigation, when viewed in terms of the above formulations, suggest that 12 year old subjects possess the competence to overcome the effects of situational and task variables. The 9 year old subjects' comparatively poorer performance on the other hand, may be attributed to an interaction between a lower level of competence and the situational variable. The cultural factor may also have some effect, although both groups of subjects belong to the same culture. The cultural age role expectations and the content of formal education at the different ages may be contributing to the results.

7.2.6.3 Stimulus relationships

The hypothesis tested was that at each age level there would be a significant relationship between the type of stimuli used and the subjects' responses on the matrix tasks.

The results indicate that there was no significant relationship between type of stimulus and the matrix responses of the younger subjects (Table 39). However, a significant relationship between type of stimulus and the matrix responses of the older subjects was observed. The older subjects did better on 3-D stimuli than on 2-D stimuli. The hypothesis then is confirmed for the older subjects but must be rejected as far as the younger subjects are concerned.

A possible explanation for these results may be the younger children have not yet acquired matrix classification ability by age 9 years. Consequently, the stimulus variable does not significantly affect their performance. The younger subjects' matrix responses reflect a comparatively low rate of success (58% on 2-D and 59% on 3-D stimuli), suggesting that their level of mastery of the matrix problem is just beginning. On the other hand, the older children achieved a success rate of 86% on the 2-D stimuli and 93% on 3-D stimuli. By age 12 years they have reached a peak in matrix classification behaviour. It would appear that at this crucial period, the stimulus variable becomes a significant factor in matrix classification. The familiar 3-D stimuli tends, at this stage of development, to increase the probability of success on the matrix tasks, as compared to the 2-D stimuli.

It is difficult to compare the results of this investigation with those of other studies in the area because the concept of stimulus familiarity is often confounded with stimulus dimensionality. This research attempted to separate these two aspects.

Further research needs to be done to achieve some measure of external validity of research findings in this area.

TABLE 46 : SUMMARY OF A SEX X AGE X TYPE OF STIMULI ANALYSIS OF VARIANCE OF THE SCORES OF 120 SUBJECTS ON THE MATRIX TASKS

SOURCE OF VARIANCE	SS	df	MS	F	p
Between Subjects	1 425,433	1			
Sex	10,416	1	10,416	1,162	>0,05
Age	360,150	1	369,150	40,177	<0,01**
Sex x Age	15,000	1	15,000	1,673	>0,05
S' Within Group Error	1 039,867	116	8,964		
Within Subjects	723,500				
Stimuli	28,016	1	28,016	47,890	<0,01**
Sex x Stimuli	,068	1	,068		
Age x Stimuli	,400	1	,400		
Age x Sex x Stimuli	16,007	1	16,007	27,362	<0,01**
Stimuli x Subject Within Group Error	67,880	116	,585		

** = Significant beyond 0,01 level

From the table it can be seen that the following variables were significant beyond the 99% level of confidence:

1. Age (F (1,116) = 40,177, p <0,01)
2. Stimuli (F (1, 116) = 47,890, p < 0,01)
3. Age x Sex x Stimuli interaction (F (1, 116) = 27,362, p < 0,01)

These findings are elaborated below with reference to the appropriate portion of the table (Table 47, page 139).

TABLE 47 : MEAN SCORES OF THE YOUNGER (N=60) AND OLDER (N=60) SUBJECTS ON THE MATRIX TASKS

	SUBJECTS	
	YOUNGER	OLDER
MEANS	9,08	13,98

From the table it can be seen that the older subjects obtained a mean of 13,98 and the younger subjects 9,08. (The maximum possible score was 18). The older subjects, therefore, did better on the matrix tasks than did the younger subjects.

TABLE 48 : MEAN SCORES OF 120 SUBJECTS ON THE MATRIX TASKS USING 2-D AND 3-D STIMULI

	STIMULI	
	2-D	3-D
MEANS	5,42	6,11

From the above table it can be seen that the subjects obtained a mean of 5,42 on 2-D stimuli and 6,11 on 3-D stimuli. (The maximum possible score was 9). The subjects did better on 3-D stimuli than on 2-D stimuli.

TABLE 49 : AN AGE X SEX X TYPE OF STIMULI SUMMARY TABLE OF THE MEAN SCORES OF SUBJECTS ON THE MATRIX TASKS

		STIMULI	
SEX	AGE GROUP	2-D	3-D
MALES	Younger Older	4,47 6,83	5,33 7,07
FEMALES	Younger Older	4,03 6,37	4,13 7,70

The maximum possible score in each cell was 9. From the table it can be seen that the younger males scored higher ($\bar{X}$ = 5,33) on the 3-D stimuli than did the younger females ($\bar{X}$ = 4,13). The older males scored lower ($\bar{X}$ = 7,07) on the 3-D stimuli than did the older females ($\bar{X}$ = 7,70). This accounts for the significant sex x age type of stimuli interaction.

The sex variable and the sex x age, sex x stimuli, and age x stimuli interactions were found to be not significant.

7.3.1 Discussion of results

The significant age differences obtained through the analysis of variance indicates that age has a significant effect on success on the matrix classification tasks. The older subjects score consistently higher than do the younger subjects. The mean score (9,08) of the younger subjects reflect a success rate of just over 50% while the mean score of the older subjects (13,98) reflect a success rate of 78%. This suggests that by age 9 years, matrix classification behaviour is beginning to emerge while by age 12 years it is nearing completion.

The significant stimulus difference (Table 48) indicates that subjects score higher on the matrix tasks using 3-D stimuli than they do with 2-D stimuli. This was to be expected as the 3-D stimuli are more familiar to the subjects than the 2-D stimuli. Subjects are assumed to be more familiar with balls and blocks than they are with geometric shapes such as triangles, squares and circles which are two-dimensional representations of three-dimensional real objects. MacKay, Fraser and Ross (1970) compared matrix responses on 2-D stimuli of the type used in this study and on 3-D stimuli drawn from a different domain, requiring seriation of height and diameter of plastic cylinders. They found that the subjects did better on the 2-D stimuli than on the 3-D stimuli. However, the stimulus attributes differed from the one set (colour and shape) to the other (height and diameter), so the dimensionality of the stimuli are not directly comparable. Similar problems are encountered with other studies in the area (e.g., Wei, Lavatelli and Jones, 1971).

The significant age x sex x stimuli interaction suggests that the effect the stimulus variable has on the responses of males and females is not consistent for both age groups. In this investigation, the 3-D stimuli appears to have positively influenced the scores of younger males while its effect on the older males has been in a negative direction (lower score than females). This sex involvement could be due to chance only, since this is the only instance in which sex has been involved in a significant effect.

7.4 SUMMARY OF RESULTS : MATRIX CLASSIFICATION RESPONSES

From the preceeding discussion, it will be noted that the age variable was found to be significantly related to matrix classification responses. This finding was consistent in both the chi-square analysis and the analysis of variance. The older subjects did better on the matrix tasks than did the younger subjects.

As far as the stimulus variable was concerned, chi-square analysis revealed a significant relationship between type of stimuli and success on the matrix tasks among the older subjects. This relationships was not significant among the younger subjects. The stimulus variable was found to be significant by the analysis of variance. As the analysis of variance is the more powerful of the two techniques, and since the age x stimuli interaction was not significant, it is reasonable to assume that the stimulus variable does have a significant effect on the matrix responses of the subjects. Subjects do better on the familiar 3-D stimuli than on the 2-D stimuli.

The sex variable was found to be not significant by both chi-square analysis and the analysis of variance. This is a consistent finding throughout this research and in the literature (e.g., MacKay, Fraser and Ross, 1970). In fact, the absence of sex differences has been taken for granted by many investigators who have not even considered it in their studies (e.g., Bruner and Kenney, 1967; Wei, Lavatelli and Jones, 1971). However, it would appear unwise to ignore the sex variable completely because of the significant age x sex x type of stimuli interaction reported.

CHAPTER EIGHT

COMPARISON OF FREE AND MATRIX CLASSIFICATION BEHAVIOURAL RESPONSES

8.1 INTRODUCTION

In Chapter Six and Seven, the free and matrix classification behavioural responses of the children were examined with emphasis on the relationship between sex, age, and stimulus variables and these responses. In this section, the free and matrix classification behavioural response of the subjects are compared. This is expected to provide some information on whether the subjects are equally capable of performing both free and matrix classification tasks, or if they find one easier than the other. Since both tasks were performed by the same subjects, using the same stimuli, any differences observed may be attributed to the task factor.

As has been the practice so far, the responses have been analysed by nonparametric and parametric techniques.

8.2 FREE CLASSIFICATION VERSUS MATRIX CLASSIFICATION : NONPARAMETRIC ANALYSIS

In comparing the free and matrix classification performance of the subjects through nonparametric analyses the initial response of the subjects on the free classification task was taken as the response measure. The reason for this was that there were no significant changes in performance among the three free classification trials (See Chapter Six). The second and third trials provided no additional information. Furthermore, as explained in Chapter Six, some of the subjects gave their best response on the first trial and retrogressed to less sophisticated responses on the second and third trials. For these reasons, the first trial responses seemed the logical choice.

The response measure for the matrix was also the response on the first matrix trial (colour x shape). Again, the reason for this was that no significant differences in performance among the three trials had been observed (See Chapter Seven), so that the first trial provided all the information required for the purposes of comparison.

To compare free classification responses with matrix classification responses, the data were cast into four 2 x 2 contingency tables one for each age group of subjects (younger and older) with each set of stimuli (2-D and 3-D). The responses of each of the 60 subjects were treated thus:

1. Each subject's free classification response on the first trial was dichotomized into uni-dimensional and multi-dimensional categories. This was considered relevant to the investigation because, in theoretical terms (See Chapter Two) the subject cannot solve a matrix problem until he acquires the ability to focus attention simultaneously on two attributes of the stimulus. Therefore, only subjects who give multi-dimensional responses on the free classification task ought to be able to solve the matrix task.

2. The subject's response on the first matrix task (colour x shape) was scored correct or incorrect (See Chapter Five).

Each of the subject's responses was placed in one of the four cells. For example, if a subject gave a uni-dimensional response on the free classification task and a correct response on the matrix task, a tally was placed in the free classification uni-dimensional response column and the matrix correct row.

If one considers and accepts that a multi-dimensional free classification response is a requisite for success on the matrix task, then one can assume that subjects who give multi-dimensional free classification responses and solve the matrix problem correctly have given consistent responses. In the same way, subjects who give uni-dimensional free classification responses and fail on the matrix task may also be assumed to have given consistent responses. Subjects who give multi-dimensional free classification responses and fail on the matrix task, or give uni-dimensional free classification responses and succeed on the matrix task, may be assumed to have given inconsistent responses.

From the point of view of statistical analysis, it was decided to investigate the relationship between the proportion of consistent responses and the proportion of inconsistent responses. Since the same subjects performed both tasks, the proportions are correlated. McNemar, 1955, (in Hays, 1963) has devised a technique for testing the equality of two correlated proportions. The technique yields a chi-square with one degree of freedom and is the test used in this set of analyses.

TABLE 50 : RESPONSES OF THE YOUNGER SUBJECTS (N=60) ON THE FIRST FREE CLASSIFICATION TRIAL AND THE FIRST MATRIX TASK USING 2-D STIMULI

		FREE CLASSIFICATION		TOTAL
		UNIDIMENSIONAL	MULTIDIMENSIONAL	
MATRIX	CORRECT	29	12	32
	INCORRECT	21	7	28
TOTAL		41	19	60

$X^2(1) = 5,555 \quad p < 0,05$

From the data above, it can be seen that there was a significant relationship between the proportion of subjects who gave consistent responses and those who gave inconsistent responses, using 2-D stimuli. Of the 19 subjects who gave multi-dimensional free classification responses, 63,2% succeeded on the matrix task. Of the 41 subjects who gave uni-dimensional free classification responses, 51,2% failed on the matrix task. This suggests that the dimensionality of the free classification response is a good predictor of performance on the matrix task. Subjects who give multi-dimensional free classification responses are more likely to succeed on the matrix tasks.

From the data in Table 50, it can also be noted that while only 32% (19/60) of the subjects gave multi-dimensional free classification responses, 53% (32/60) succeeded on the matrix task. This suggests that 9 year old subjects find matrix task easier than the free classification task when using 2-D stimuli.

The same relationships were next examined with 3-D stimuli. The data are presented below:

TABLE 51 : RESPONSES OF THE YOUNGER SUBJECTS (N=60) ON THE FIRST FREE CLASSIFICATION TRIAL AND THE FIRST MATRIX TASKS USING 3-D STIMULI

		FREE CLASSIFICATION		TOTAL
		UNIDIMENSIONAL	MULTIDIMENSIONAL	
MATRIX	CORRECT	20	9	29
	INCORRECT	27	4	31
TOTAL		47	13	60

$X^2(1) = 9{,}375 \quad p < 0{,}01$

The data above indicates that there was a significant relationship between the proportion of subjects who gave consistent responses and those who gave inconsistent responses using 3-D stimuli. Of the 13 subjects who gave multi-dimensional free classification responses, 69% also succeeded on the matrix. Of the 47 subjects who gave uni-dimensional responses, 57% failed on the matrix. Again, it can be seen that the dimensionality of the free classification response is a good predictor of success on the matrix task.

From the data in Table 51, it may also be noted that while only 22% (13/60) of the subjects gave multi-dimensional free classification responses, 48% (29/60) correctly solved the matrix. This again suggests that 9 year old subjects find it easier to solve the matrix than to give a multi-dimensional free classification response when using 3-D stimuli.

From the data in Tables 50 and 51, it appears that, irrespective of the type of stimuli used, 9 year old subjects find it easier to solve the matrix problem than to give a multi-dimensional free classification response.

The next step was to examine the same relationships among the 12 year old subjects. The data are presented below:

TABLE 52 : RESPONSES OF THE OLDER SUBJECTS (N=60) ON THE FIRST FREE CLASSIFICATION TRIAL AND THE FIRXT MATRIX TASK USING 2-D STIMULI

	FREE CLASSIFICATION		TOTAL
	UNIDIMENSIONAL	MULTIDIMENSIONAL	
MATRIX CORRECT	16	29	45
INCORRECT	6	9	15
TOTAL	22	38	60

$X^2(1) = 1,44 \quad p > 0,05$

There was no significant relationship between the proportion of subjects who gave consistent responses and those who gave inconsistent responses. The dimensionality of the older subjects' free classification responses and success on the matrix tasks, using 2-D stimuli, were not related.

This relationship was next investigated for the 3-D stimuli. The data are presented in Table 53 (page 148).

TABLE 53 : RESPONSES OF THE OLDER SUBJECTS (N=60) ON THE FIRST FREE CLASSIFICATION TRIAL AND THE FIRST MATRIX TASK USING 3-D STIMULI

		FREE CLASSIFICATION		TOTAL
		UNIDIMENSIONAL	MULTIDIMENSIONAL	
MATRIX	CORRECT	25	25	50
	INCORRECT	5	5	10
TOTAL		30	30	60

$X^2(1) = 12{,}033 \quad p < 0{,}01$

There was a significant relationship between the proportion of subjects who gave consistent responses and those who gave inconsistent responses. Of the 30 subjects who gave multi-dimensional free classification responses, 83% also succeeded on the matrix task. Of the 30 subjects who gave uni-dimensional free classification responses, 17 failed on the matrix task.

From the table it can also be seen that 83% (50/60) of the subjects succeeded on the matrix task while only 50% (30/60) of the subjects gave multi-dimensional free classification responses using 3-D stimuli. This suggests that the older subjects, using 3-D stimuli found it easier to solve the matrix task than to give multi-dimensional free classification responses.

The results obtained may be summarized as follows:

1. Significant relationships between the dimensionality of the free classification responses and success on the matrix task were observed among the younger subjects, using 2-D stimuli and 3-D stimuli and among the older subjects using 3-D stimuli. In each case, it was found that the subjects found it easier to solve the matrix problem than to give a multi-dimensional free classification response.

2. No significant relationship was observed among the older subjects, using 2-D stimuli, between the dimensionality of their free classification responses and success on the matrix task.

These results are discussed below.

8.2.1 Discussion of Results : Nonparametric Analyses

From the preceeding presentation, it will be noted that the McNemar test for correlated proportions (Hays, 1963) revealed that there was a significant relationship between the dimensionality of the subject's free classification response and success on the matrix task in three of the four analyses conducted.

These were:

1. Younger subjects using 2-D stimuli.
2. Younger subjects using 3-D stimuli.
3. Older subjects using 3-D stimuli.

Alternatively, there is a significant relationship between the proportion of subjects giving consistent responses and the proportion of subjects giving inconsistent responses.

There was no significant relationship between the dimensionality of free classification responses and success on the matrix task among the older subjects using 2-D stimuli (Table 52). It can be seen that the percentage of subjects who gave multi-dimensional free classification responses and succeeded on the matrix task (76%) was similar to the percentage who gave unidimensional free classification responses and failed on the matrix task (73%).

It was also noted that in three of the four analyses, the subjects solved the matrix problem more frequently than they gave multi-dimensional free classification responses (Tables 50, 51, and 53). Although this relationship did not reach significance among the older subjects using 2-D stimuli (Table 52), the trend was still present. These results suggest that 9 year old and older subjects find the matrix task easier to solve them to give a multi-dimensional free classification response.

The results discussed thus far raise certain issues that require attention. One of these is the comparatively high percentage of inconsistent responses given by subjects. The other is the finding that subjects find the matrix task easier than the free classification task. Piaget's (Inhelder and Piaget, 1964) and Bruner's (1967) formulations assume that the same cognitive structures are responsible for both tasks. The subjects who respond consistently support this assumption. However, the inconsistent responders contradict the assumption, as does the finding that the matrix task is easier.

This suggests several possibilities. The theories themselves may need close examination. Or, it could be that the results that were obtained were due to the specific methodology used in this investigation. The unique combination of the age group of the subjects, the instructions associated with each task, and the particular way in which the data were scored, could have had an effect on the results. For instance, the free classification task required the subject to respond on the basis of his understanding and interpretation of the verbal instruction. In the matrix task, on the other hand, there is more than just the verbal cue to go on. The instruction is given correctness by the experimenter actually constructing part of the matrix. The subject is required to recognize the basis of similarity already determined by the experimenter. He therefore finds the matrix task easier. This is somewhat analagous to the recognition versus recall issue in memory testing (Hilgard, Hilgard and Atkinson, 1979), where it is found that recognition is easier than recall.

Another possibility could be that the free classification and matrix tasks may be quite independent of each other. Nobody has studied these two tasks within the same individual using the same set of stimuli. This area needs further research.

8.3 FREE CLASSIFICATION : VERSUS MATRIX CLASSIFICATION : PARAMETRIC ANALYSES

In order to compare the behavioural responses of the subjects on the free classification and the matrix tasks, the data used in Chapters Six and Seven were subjected to a 2 x 2 x 2 x 2 (age x sex x type of stimuli x task) analysis of variance with repeated measures on the last two factors. (Type of Stimuli and Task). The results are presented in Table 54 (page 152). It may be noted that the figures that went into the analyses were obtained as described previously in Chapter Five. For each subject, the figure reflects a combined score of three free classification trials and three matrix trials.

TABLE 54 : SUMMARY TABLE OF AN AGE X SEX X TYPE OF STIMULI X TASK ANALYSIS OF VARIANCE WITH REPEATED MEASURES ON THE TYPE OF STIMULI AND TASK FACTORS (N = 30 PER GROUP)

SOURCE OF VARIATION	SS	df	MS	F	p
Age	403,337	1	403,337	46,979	<0,01**
Sex	10,209	1	10,209	1,189	
Age x Sex	10,208	1	10,208	1,189	
Subject Within Group Error	995,996	116	8,586		
Stimuli	12,679	1	12,679	12,467	<0,01**
Age x Stimuli	,008	1	,008		
Sex x Stimuli	,133	1	,133		
Age x Sex x Stimuli	7,501	1	7,501	7,376	<0,01**
Subject x Stimuli Within Group Error	117,933	116	1,017		
Task	940,800	1	940,800	252,767	<0,01**
Age x Task	45,633	1	45,633	12,260	<0,01**
Sex x Task	1,874	1	1,874	,503	
Age x Sex x Task	5,210	1	5,210	1,400	
Task x Subject Within Group Error	431,733	116	3,722		
Stimuli x Task	15,408	1	15,408	3,244	<0,05*
Age x Stimuli x Task	1,409	1	1,409	,376	
Sex x Stimuli x Task	,001	1	,001		
Age x Sex x Stimuli x Task	8,531	1	8,531	1,796	
Stimuli x Subject Within Group Error	550,900	116	4,749		

** Significant at 0,01 level
* Significant at 0,05 level

From the above table, it can be seen that the following factors were significant:

1. Age (F (1, 116) = 46, 976, p <0,01)
2. Type of Stimuli (F (1, 116) = 12, 467, p <0,01)
3. Task (F (1, 116) = 252,260, p <0,01)

The following interactions were also significant:

1. Age x Task (F (1, 116) = 12, 260, p <0,01)
2. Type of Stimuli x Task (F (1, 116) = 3, 244, p <0,05)
3. Age x Sex x Type of Stimuli (F (1, 116) = 7, 376, p <0,01)

The findings are examined in detail below, with reference to the appropriate data.

TABLE 55 : MEAN SCORES OF THE YOUNGER (N=60) AND OLDER (N=60) SUBJECTS ON THE FREE CLASSIFICATION AND MATRIX TASKS

	SUBJECTS	
	YOUNGER	OLDER
Means	13,80	21,13

The above data indicates that the older subjects score significantly higher ($\bar{X}$ = 21,13) than do the younger subjects ($\bar{X}$ = 13,80). These means reflect a combined score on the free classification and matrix tasks.

TABLE 56 : MEAN SCORES OF THE SUBJECTS (N=120) ON 2-D AND 3-D STIMULI

	STIMULI	
	2-D	3-D
Means	8,41	9,06

It can be seen that the subjects performed better on 3-D stimuli ($\bar{X}$ = 9,06) than they did on 2-D stimuli ($\bar{X}$ = 8,41). These means reflect the combined score on the free classification and matrix tasks.

TABLE 57 : MEAN SCORES OF SUBJECTS (N=120) ON THE FREE CLASSIFICATION AND MATRIX TASKS

	FREE CLASSIFICATION	MATRIX
Means	5,93	15,53

From the data above, it can be seen that the subjects scored significantly higher on the matrix task ($\bar{X}$ = 15,53) than they did on the free classification task ($\bar{X}$ = 5,93). These means reflect the combined score obtained by each subject across the three trials on each type of task.

TABLE 58 : MEAN SCORES OF THE YOUNGER (N=60) AND OLDER (N=60) SUBJECTS ON THE FREE CLASSIFICATION AND MATRIX TASKS

AGE GROUP	TASK	
	FREE CLASSIFICATION	MATRIX
Younger	4,72	9,08
Older	7,15	13,98

The significant Age x Task interaction may be explained with reference to the table above. The younger subjects scored higher on the matrix task ($\bar{X}$ = 9,08) than did the older subjects on the free classification task ($\bar{X}$ = 7,15). This suggests that the influence of the age factor is not the same on both tasks.

TABLE 59 : MEAN SCORES OF SUBJECTS (N=120) ACCORDING TO THE STIMULUS AND TASK VARIABLES

	TASK	
STIMULI	FREE CLASSIFICATION	MATRIX
2-D 3-D	2,98 2,95	5,43 6,11

From the table above, it can be seen that the subjects scored higher on the free classification tasks with 2-D stimuli ($\bar{X}$ = 2,98) than with 3-D stimuli ($\bar{X}$ = 2,95). On the matrix tasks, they scored higher on the 3-D stimuli ($\bar{X}$ = 6,11) than they did on the 2-D stimuli ($\bar{X}$ = 5,43). This accounts for the significant type of stimuli x task interaction.

TABLE 60 : MEAN SCORES OF SUBJECTS (N=120) ACCORDING TO AGE, SEX, AND TYPE OF STIMULI*

SEX	AGE GROUP	STIMULI	
		2-D	3-D
Male	Younger Older	3,47 5,27	4,02 5,30
Female	Younger Older	3,10 4,98	3,22 5,58

*The means reflect a combined score on the free classification and matrix tasks

From the above table, it can be seen that each sub-group of subjects scored higher on the 3-D stimuli than on 2-D stimuli. Also, the older subjects of both sexes did consistently better than the younger subjects on both 2-D and 3-D stimuli. However, while the younger males scored higher than the younger females on both 2-D and 3-D stimuli, this consistent pattern did not prevail among the older subjects. The older females scored higher ($\bar{X}$ = 5,58) than the older males ($\bar{X}$ = 5,30) on the 3-D stimuli. On the 2-D stimuli, the older males scored higher ($\bar{X}$ = 5,27) than the older females ($\bar{X}$ = 4,98). This possibly explains the significant age x sex x type of stimuli interaction.

To summarize, the following main effects were significant at the 0,01 level:

1. Age : The older subjects did better than the younger subjects on the combined free classification and matrix responses.

2. Stimuli: The subjects scored higher on 3-D stimuli than on 2-D stimuli.

3. Task: Subjects scored higher on the matrix tasks than on the free classification tasks.

The following two-factor interactions were significant :

1. Age x Task
2. Stimuli x Task.

The only three-factor interaction that was significant was the age x sex x stimuli interaction.

The sex variable and all the other interactions were not significant. The results are discussed below.

8.3.1 Discussion of Results : Parametric Analyses

The only new variable that was introduced in the four-factor analysis of variance was the task variable.

Since the results pertaining to the age, sex, and type of stimuli variables have already been discussed in Chapters Six and Seven and the findings already reported have not been contradicted in this analysis, these will not be discussed again. The discussion therefore, is confined to the effect of the task variable and all the significant interactions involving this variable.

The task variable was found to be significant (Table 57). Subjects scored higher on the matrix tasks than on the free classification tasks. This confirms the hypothesis that there would be significant differences in the performance of subjects between the free classification and matrix tasks. However, the direction on the difference is surprising. Although no study has made this comparison on the same group of subjects using the same set of stimuli, Wei, Lavatelli and Jones (1971) reported that 80% of second-grade children could successfully free classify while only 30% could solve the matrix task. This would suggest that free classification behaviour is manifested earlier than matrix classification behaviour. This has also been implied by Piaget (1964) and Bruner (1967) in their argument that the ability to simultaneously consider two attributes of the stimulus develops later than the ability to consider one attribute at a time.

The apparent contradiction may be explained in several ways. It must be remembered that for the parametric analyses, all three trials on each task was combined to give a total score for that task. Because the matrix was structured, requiring the subject to complete a task already begun by the experimenter, the subject probably found it easier to do so. The free classification tasks on the other hand provided no concrete cues as to what was required beyond the verbal instructions given. This meant that the subject had to mentally extract the relevant attributes. Since no mention was made by the experimenter as to how many attributes should be utilised in any one trial, subjects chose to use a single attribute. The reclassification trials simply required the subject to sort in a different way. No comment was made as to the acceptibility of his initial response. Consequently, subjects continued with uni-dimensional responses, thus earning low "scores". It must be conceded that, to the subject, a response based on colour is certainly different from one based on size, and hence meets the requirements of the instructions.

Secondly, it is possible that, for 9 year old and older subjects at least, the matrix task is easier than the free classification task. If it is accepted that by age 9 years, subjects are already functioning at the concrete operational level, then it follows that they possess the ability to solve the matrix task. The recognition versus recall analogy referred to earlier would then, seem to be the more crucial issue in the high rate of success recorded on the matrix task.

The third possibility that may account for the apparently contradictory findings is that some subjects gave their best response on the first free classification trial. On being asked to reclassify, they sometimes suspected trickery of some sort and fell back on less sophisticated responses on subsequent trials. Also, a subject who gave a three-dimensional response (shape x colour x size) as his first response, continued with less sophisticated responses in subsequent trials, in order to avoid repetition. In this way subjects lost points on the reclassification trials.

However, performance on Trials Two and Three are not the primary source for the significant difference observed between matrix and free classification responses. The nonparametric analysis, which considered only the initial responses of subjects also revealed that subjects did better on the matrix tasks than on the free classification tasks. This suggests that the subjects did find the matrix tasks easier than the free classification tasks, regardless of whether only initial responses or the combined responses of the three trials on each task were taken as the response measure. Since, as has been emphasized repeatedly, the child needs to attend to two attributes of the stimuli as a prerequisite to succeed on the matrix task, the conclusion to be drawn is that the standard instructions for the free classification tasks need revision. Somehow the child must be encouraged to make his free classification response a multi-attributed response. Only then will it be known if the subjects can or cannot give multi-dimensional free classification responses. It would appear that many subjects gave uni-dimensional free classification responses as a matter of convenience particularly as these responses did meet the requirements of the experimenter's instructions.

The significant interactions between age and task, and type of stimuli and task, suggest that while the task variable is itself highly significant, it is, to some extent, modified by the age, and stimulus variables. The age of the subjects and the type of stimuli used to assess free and matrix ability cannot be ignored.

8.4 COMPARISON OF NONPARAMETRIC AND PARAMETRIC RESULTS

The nonparametric analyses revealed significant differences between free and matric classification responses among the younger subjects on both 2-D and 3-D stimuli and among the older subjects on 3-D stimuli. In each of the three instances, subjects found the matric tasks easier than the free classification tasks. This difference did not emerge among the older subjects using 2-D stimuli, suggesting a possible type of stimuli x task interaction.

The analysis of variance results are essentially the same. The task variable was significant ($F (1, 116) = 252,767$) beyond the 0,01 level. The subjects did better on the matrix task than on the free classification task (Table 57). The possible type of stimuli x task interaction suggested by nonparametric analyses was found to be significant by the analysis of variance.

In conclusion, it can be stated that both parametric and nonparametric analyses lead to the same end result, that is, 9 year old and 12 year old subjects do consistently better on the matrix tasks than on the free classification task with both 2-D and 3-D stimuli. The significant stimuli x task and age x task interactions suggest that these variables must be taken into account when investigating free and matrix classification behaviour.

It may be pointed out that the procedure for quantification of responses for purposes of parametric analyses did not materially affect the results. This may be inferred from the fact that the nonparametric analyses considered only a successful free classification response, that is, a response based on similarity regardless of the number of dimensions employed. The fact that both parametric and nonparametric techniques led to the same end results gives added validity to the findings.

CHAPTER NINE

RESULTS AND DISCUSSION : VERBAL RESPONSES

9.1 INTRODUCTION

It will be remembered from Chapter Four that each subject was asked to verbally justify each of his behavioural responses on each trial of the free classification and matrix tasks. In this chapter the children's ability to justify their behavioural responses is examined.

For the purposes of analysis, only the verbal justification of free classification behavioural responses based on similarity, irrespective of the dimensions employed, were considered.

The scoring of the verbal responses have been described in detail in Chapter Five. It will be recalled that a plus (+) score was awarded to a verbal response which was of the same level as the behavioural response. The plus rating did not in any way differentiate between the uni-dimensional and multi-dimensional free classification behavioural response. It only indicated that the subject's behavioural and verbal responses were of the same level. A minus (-) rating indicated that the subject's behavioural response was of a higher or lower level than his verbal response.

The verbal response on all three trials of each of the free classification and matrix tasks were pooled, giving one frequency count for the total number of free classification response adequately justified and one for matrix responses adequately justified (+ rated responses). In the same way two frequency counts were obtained for inadequate (- rated) responses. The total possible frequency was, therefore, 90 (30 subjects x three trials), for the free classification trials and 90 for the matrix trials for each group of subjects. A frequency of 90 for the + rated scores indicate that every subject in the group gave an acceptable behavioural response on each trial and also adequately justified each behavioural response. A frequency of 90 for the - rated scores indicate that every subject in the group gave an acceptable behavioural response but failed to adequately justify each response. It must be noted that the total possible frequency was not attained in any group because the unacceptable free classification responses and incorrect matrix responses were excluded from the analyses.

The effect of the sex, age, stimulus, and task variables on the adequacy of verbal justification were investigated using the data described above. The nature of the data precluded parametric analyses. Therefore, the data were analysed through only the nonparametric chi-square technique. The results are presented below.

9.2 SEX RELATIONSHIPS

The relationship between the sex variable and the adequacy of verbal responses was investigated for each age group on each of the free classification and matrix tasks with each set of stimuli. This resulted in eight 2 x 2 (sex x adequacy/inadequacy of responses) chi-squares being computed. In each contingency table, the frequency reflects the total number of responses that were adequately or inadequately justified across the three trials of each task. The data are presented below.

TABLE 61 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER MALES AND FEMALES ON THE FREE CLASSIFICATION TASKS USING 2-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male Female	50 54	26 23	76 77
TOTAL	104	49	153

$X^2(1) + 0,330 \quad p > 0,05$

There was no significant relationship between sex and adequate/ inadequate verbal justification of the free classification responses of the younger subjects, using 2-D stimuli.

TABLE 62 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER MALES AND FEMALES ON THE FREE CLASSIFICATION TASKS USING 2-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male	49	40	89
Female	45	41	86
TOTAL	94	81	175

$X^2(1) + 0,131 \quad p > 0,05$

There was no significant relationship between sex and adequate/inadequate verbal justification of the free classification responses of the older subjects, using 2-D stimuli.

From the data in Tables 61 and 62, it can be seen that there was no relationship between sex and the verbal justification of free classification responses of both the younger and older subjects, using 2-D stimuli. It was next decided to examine the same relationship, using 3-D stimuli. The results are presented below.

TABLE 63 : FREQUENCY OF ADEQUATE AND INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER MALES AND FEMALES ON THE FREE CLASSIFICATION TASKS USING 3-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male	44	34	78
Female	56	25	81
TOTAL	100	59	159

$X^2(1) = 2,737 \quad p > 0,05$

There was no significant relationship between sex and adequate/inadequate verbal justification of the free classification responses of the younger subjects, using 3-D stimuli.

TABLE 64 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER MALES AND FEMALES ON THE FREE CLASSIFICATION TASKS USING 3-D STIMULI

SEX	VERBAL JUSTIFICATIONS		TOTAL
	ADEQUATE	INADEQUATE	
Male	51	37	88
Female	65	24	89
TOTAL	116	61	177

$X^2(1) = 4{,}451 \quad p < 0{,}05$

There was a significant relationship between sex and adequate/inadequate verbal justification of the free classification responses of the older subjects, using 3-D stimuli. A greater percentage of the responses of females (73%) than of the males (58%) were adequately justified.

From the data in Tables 63 and 64, it can be seen that, when 3-D stimuli were used, the sex variable was significantly related to the adequacy of the justification of free classification responses of the older subjects. Older females adequately justified their responses more frequently than did the older males. This relationship was not observed among the younger subjects. Nor was it observed among the older and younger subjects, using 2-D stimuli.

It was next decided to examine the relationship between the sex variable and the adequacy of verbal justification on the matrix tasks. The results are tabled below. (Table 65, page 164)

TABLE 65 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER MALES AND FEMALES ON THE MATRIX TASKS USING 2-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male	41	15	56
Female	33	30	63
TOTAL	74	45	119

$X^2(1) = 5,465 \quad p < 0,05$

There was a significant relationship between sex and adequate/inadequate verbal justification of the matrix responses of the younger subjects using 2-D stimuli. A greater percentage of the responses of males (55%) than of the females (45%) were adequately justified.

TABLE 66 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER MALES AND FEMALES ON THE MATRIX TASKS USING 2-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male	50	28	78
Female	65	15	80
TOTAL	115	43	158

$X^2(1) = 5,857 \quad p < 0,05$

There was a significant relationship between sex and adequate/inadequate verbal justification of the matrix responses of the older subjects, using 2-D stimuli. A greater percentage of the response of females (81%) than of the males (64%) were adequately justified.

From the data in Tables 65 and 66, it can be seen that when 2-D stimuli were used to perform the matrix tasks, the older female subjects adequated justified their responses more frequently than did the older male subjects. The younger males, on the other hand adequately justified their responses more frequently than the younger females. The same relationship was next examined, with the 3-D stimuli. The results are presented below.

TABLE 67 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER MALES AND FEMALES ON THE MATRIX TASKS USING 3-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male	41	15	56
Female	37	17	54
TOTAL	78	32	110

$X^2(1) = 0,292$ $p > 0,05$

There was no significant relationship between sex and adequate/inadequate verbal justification of the matrix responses of the younger subjects, using 3-D stimuli.

TABLE 68 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER MALES AND FEMALES ON THE MATRIX TASKS USING 3-D STIMULI

SEX	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Male	72	10	82
Female	78	7	85
TOTAL	150	17	167

$X^2(1) = 0,713 \quad p > 0,05$

There was no significant relationship between sex and adequate/inadequate verbal justification of the matrix responses of the older subjects, using 3-D stimuli.

The results of the analysis of the relationship between sex and the adequacy of the subject's verbal justification of his behavioural responses may be summarised as follows:

1. Females adequately justified their responses more frequently than the males in the following instances:

   (a) The free classification responses of older subjects, using 3-D stimuli (Table 64).

   (b) The matrix responses of the older subjects, (Table 66) using 2-D stimuli.

2. The younger male subjects adequately justified their matrix responses, using 2-D stimuli more frequently than did the females (Table 65)

3. All the other analyses yielded results that were statistically not significant. The sex variable was, therefore, collapsed for the subsequent analyses.

9.3 AGE RELATIONSHIPS

In order to investigate age differences in the adequacy of the verbal responses of subjects, the contingency tables were constructed by counting the frequency of adequate and inadequate responses given by subjects of each age group. Four contingency tables were drawn up, one for each of the following:

1. Free classification using 2-D stimuli
2. Free classification using 3-D stimuli
3. Matrix classification using 2-D stimuli
4. Matrix classification using 3-D stimuli

The maximum frequency possible in each cell was 180 (60 subjects x 3 trials).

The results are presented below.

TABLE 69 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATION GIVEN BY YOUNGER AND OLDER SUBJECTS ON THE FREE CLASSIFICATION TASKS USING 2-D STIMULI

AGE GROUP	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Younger	104	49	153
Older	94	81	175
TOTAL	198	130	328

$X^2(1) = 6,936 \quad p < 0,01$

There was a significant relationship between age and adequate/inadequate verbal justification of the free classification responses of the subjects, using 2-D stimuli. A greater percentage (68%) of the responses of younger subjects than of the older subjects (54%) were adequately justified. Of the total number of inadequate justifications, a higher percentage (62%) were given by the older subjects than by the younger subjects (32%)

TABLE 70 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER AND OLDER SUBJECTS ON THE FREE CLASSIFICATION TASKS USING 3-D STIMULI

AGE GROUP	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Younger Older	100 116	59 61	159 177
TOTAL	216	120	336

$X^2(1) = 0,501 \quad p > 0,05$

There was no significant relationship between age and adequate/inadequate verbal justification of the free classification responses of the subjects, using 3-D stimuli.

TABLE 71 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER AND YOUNGER SUBJECTS ON THE MATRIX TASKS USING 2-D STIMULI

AGE GROUP	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Younger Older	74 115	45 43	119 158
TOTAL	189	88	277

$X^2(1) = 3,517 \quad p > 0,05$

There was no significant relationship between age and adequate/inadequate verbal justification of the matrix responses of the subjects, using 2-D stimuli. However, the trend is still present indicating that the older subjects gave more adequate justifications than did the younger subjects.

TABLE 72 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATION GIVEN BY YOUNGER AND OLDER SUBJECTS ON THE MATRIX TASKS USING 3-D STIMULI

AGE GROUP	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Younger	78	32	110
Older	150	17	167
TOTAL	228	49	277

$X^2(1) = 16{,}284 \quad p < 0{,}01$

There was a significant relationship between age and adequate/inadequate verbal justification of the matrix responses of the subjects, using 3-D stimuli. A greater percentage of the responses of the older subjects (90%) than the percentage of the responses of the younger subjects (71%) were adequately justified.

The above results on the relationship between age and the adequacy/inadequacy of the verbal responses may be summarised as follows:

1. Age was significantly related to the adequacy of the verbal justification of the free classification responses of subjects, using 2-D stimuli (Table 69). The younger subjects adequately justified their responses more frequently than did the older subjects.

2. Age was also significantly related to the adequacy of the verbal justification of the matrix responses of subjects, using 3-D stimuli (Table 72). The older subjects adequately justified their responses more frequently than did the younger subjects.

3. All the other analyses yielded results that were statistically not significant.

9.4 STIMULUS RELATIONSHIPS

The relationship between the stimulus variable and the adequacy of the subjects' verbal responses was investigated. The following four contingency tables were drawn up:

1. Free classification responses of younger subjects, using 2-D stimuli and 3-D stimuli.

2. Free classification responses of older subjects, using 2-D stimuli and 3-D stimuli.

3. Matrix responses of younger subjects, using 2-D stimuli and 3-D stimuli.

4. Matrix responses of older subjects, using 2-D and 3-D stimuli.

In each table, the figures reflect the frequency of adequate and inadequate verbal justifications given by the subjects on 2-D and 3-D stimuli. The maximum response frequency possible in each cell is 180 (60 subjects x 3 trials). The results are presented below.

TABLE 73 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER SUBJECTS ON THE FREE CLASSIFICATION TASKS USING 2-D AND 3-D STIMULI

STIMULI	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
2-D 3-D	104 100	49 59	153 159
TOTAL	204	108	312

$X^2(1) = 0,889 \quad p > 0,05$

There was no significant relationship between the type of stimuli and adequate/inadequate verbal justification of the free classification responses of the younger subjects.

TABLE 74 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER SUBJECTS ON THE FREE CLASSIFICATION TASKS USING 2-D AND 3-D STIMULI

STIMULI	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
2-D	94	81	175
3-D	116	61	177
TOTAL	210	142	352

$X^2(1) = 5{,}109 \quad p < 0{,}05$

There was a significant relationship between the type of stimuli and adequate/inadequate verbal justification of the free classification responses of older subjects. A greater percentage of the responses to 3-D stimuli (66%) were adequately justified than were the responses to 2-D stimuli (54%).

TABLE 75 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER SUBJECTS ON THE MATRIX TASKS USING 2-D AND 3-D STIMULI

STIMULI	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
2-D	74	45	119
3-D	78	32	110
TOTAL	152	77	229

$X^2(1) = 1{,}948 \quad p > 0{,}05$

There was no significant relationship between the type of stimuli and the adequacy of the verbal justification of matrix responses of the younger subjects.

TABLE 76 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER SUBJECTS ON THE MATRIX TASKS USING 2-D AND 3-D STIMULI

STIMULI	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
2-D	115	43	158
3-D	150	17	167
TOTAL	265	60	325

$X^2(1) = 15{,}649 \quad p < 0{,}01$

There was a significant relationship between the type of stimuli and the adequacy of the subject's verbal justification of matrix responses. A greater percentage of the responses on 3-D stimuli were adequately justified (90%) than were the percentage of responses on 2-D stimuli (73%).

The findings with regard to the relationship between the stimulus variable and the adequacy of the subject's verbal justification of behavioural responses may be summarised as follows:

1. The stimulus factor was significantly related to the adequacy of the verbal justifications given by subjects in the following instances:

   (a) The older subjects adequately justified their free classification responses more frequently with 3-D stimuli than they did with 2-D stimuli (Table 74).

   (b) The older subjects adequately justified their matrix responses more frequently with 3-D stimuli than they did with 2-D stimuli (Table 76).

2. There was no significant relationship between the stimulus variable and the adequacy of the verbal justifications of the free classification (Table 73) and matrix responses (Table 75) of the younger subjects.

9.5 TASK RELATIONSHIPS

The relationship between the task variable and the adequacy of the subject's verbal justification of behavioural responses was investigated. This was expected to provide some information on whether subjects justified their free classification and matrix responses equally well, or they found one type of behavioural response easier to justify than the other. The data to be analysed were cast into four 2 x 2 (task x adequacy of response) contingency tables as follows:

1. Adequate/inadequate verbal justification of the free classification and matrix responses of the younger subjects, using 2-D stimuli.

2. Adequate/inadequate verbal justification of the free classification and matrix responses of the younger subjects, using 3-D stimuli.

3. Adequate/inadequate verbal justification of the free classification and matrix responses of the older subjects, using 2-D stimuli.

4. Adequate/inadequate verbal justification of the free classification and matrix responses of the older subjects using 3-D stimuli.

In each of these tables, the figures refer to the frequency of adequate and inadequate verbal justifications given by the subjects across all three trials within each task. The maximum possible response frequency in each cell was 180 (60 subjects x 3 trials). These results are presented in Table 77.

TABLE 77 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER SUBJECTS ON THE FREE CLASSIFICATION AND MATRIX TASK USING 2-D STIMULI

TASK	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Free classification	104	49	153
Matrix	74	45	119
TOTAL	178	94	272

$X^2(1) = 0,991 \quad p > 0,05$

There was no significant relationship between the task variable and the adequacy of verbal justification of free classification and matrix responses of the younger subjects, using 2-D stimuli.

TABLE 78 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY YOUNGER SUBJECTS ON THE FREE CLASSIFICATION AND MATRIX TASKS USING 3-D STIMULI

TASK	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Free classification	100	59	159
Matrix	78	32	110
TOTAL	178	91	269

$X^2(1) = 1,868 \quad p > 0,05$

There was no significant relationship between task and the adequacy of the verbal justification of free classification and matrix responses of the younger subjects, using 3-D stimuli.

From the data in Tables 77 and 78, it can be seen that irrespective of the stimuli used, the task variable was not significantly related to the adequacy of verbal justifications given by the younger subjects. The same relationship was next investigated in the older subjects. The results are presented below.

TABLE 79 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER SUBJECTS ON THE FREE CLASSIFICATION AND MATRIX RESPONSES USING 2-D STIMULI

TASK	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Free classification	94	81	175
Matrix	115	43	158
TOTAL	209	124	333

$X^2(1) = 12{,}919 \quad p < 0{,}01$

There was a significant relationship between task and the adequacy of verbal justifications given by the older subjects using 2-D stimuli. More of the matrix responses (73%) were adequately justified than were the free classification responses (54%). Also of the total number of inadequate responses, 65% were given on the free classification task and 35% on the matrix task.

TABLE 80 : FREQUENCY OF ADEQUATE/INADEQUATE VERBAL JUSTIFICATIONS GIVEN BY OLDER SUBJECTS ON THE FREE CLASSIFICATION AND MATRIX RESPONSES USING 3-D STIMULI

TASK	VERBAL JUSTIFICATION		TOTAL
	ADEQUATE	INADEQUATE	
Free classification	116	61	177
Matrix	150	17	167
TOTAL	266	78	344

$X^2(1) = 28,896 \quad p < 0,01$

There was a significant relationship between task and the adequacy of verbal justifications given by the older subjects, using 3-D stimuli. More of the matrix responses (90%) than the free classification responses (66%) were adequately justified. Of the total number of inadequate responses, 78% were given on the free classification and 22% on the matrix tasks.

From the data in Tables 79 and 80, it can be seen that, irrespective of the stimuli used, the older subjects adequately justified their matrix responses more frequently than they did their free classification responses. Alternatively, the older subjects inadequately justified the free classification responses more frequently than they did the matrix responses.

9.6 SUMMARY OF RESULTS : VERBAL RESPONSES

The results of the investigation into the adequacy of verbal responses are summarised in Table 81, page 177.

From the summary in Table 81, it can be seen that the following significant relationships were obtained:

1. Between sex and the adequacy of verbal justification of free classification responses of older subjects, using 3-D stimuli. Females adequately justified their responses more frequently than did the males.

2. Between sex and the adequacy of verbal justification of matrix responses of younger and older subjects, using 2-D stimuli.

3. Between age and the adequacy of verbal justification of free classification responses, using 2-D stimuli.

4. Between age and the adequacy of verbal justification of matrix responses, using 3-D stimuli.

5. Between type of stimulus and the adequacy of verbal justification of free classification responses of older subjects.

6. Type of stimulus and the adequacy of verbal justification of matrix responses of older subjects.

7. Between task and adequacy of verbal justification of behavioural responses of older subjects, using 2-D and 3-D stimuli.

All the other analyses yielded results that were statistically not significant.

These results are discussed below.

9.7 DISCUSSION OF RESULTS : VERBAL RESPONSES

One of the major objectives in investigating the adequacy of the subject's verbal justification of his behavioural responses was to ascertain whether there was any discrepancy between the child's classification ability as manifested through his manipulation of the stimuli, and his ability to explain and justify his behaviour through the use of language. This has an important bearing on the problem of methodology in assessing classification behaviour, particularly in terms of the variations in techniques employed by the two major theorists in this field.

Piaget (Inhelder and Piaget, 1964) initially relied totally on verbal behaviour to assess classification ability using the clinical method. According to Ginsberg and Opper (1969), Piaget later adopted the revised clinical method which reduced the emphasis on verbal description of the child's thought processes, and focused attention on what the child did with things. While the revised clinical method is less exclusively verbal than Piaget's earlier procedure, critics (e.g., Braine, 1962) feel that the method is still too verbal and therefore inadequate.

Bruner (1967), on the other hand, argues

> *"...it is not language per se that provides the recording of experience. Rather, it is a genuine restructuring of how we perceive."* 1

His argument is that telling or explaining something depends upon first have the requisite motor behaviour. In other words, the child's behavioural response is as good as a measure of his ability as is his verbal explanation. Furthermore, the verbal explanation may be inadequate not because of the lack of ability but through faults of grammar.

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1. Bruner, J.S. *et al* (1967), *Studies in Cognitive Growth*, p. 56.

In short, while Piaget (1964) assesses classification ability by looking at both behavioural and verbal responses, Bruner (1967) believes that the behavioural responses are sufficient.

From the review of literature, it was noted that a variety of factors affected the adequacy of the child's verbal justification of his behavioural response. Deregowski and Serpell (1971) found the cultural environment to be a significant factor. They found that 95% of third-grade Scottish children could adequately justify their behavioural responses while only 29% of Zambian children of the same grade could do so. Price-Williams (1962) found the stimulus factor to have an effect on the kind of verbal justifications given. When classifying animal stimuli, the children justified their responses in terms of concrete attributes, such as colour and size. The same children justified their responses in terms of the abstract feature of edibility, when classifying plant stimuli. Wei, Lavatelli and Jones (1971) found the socio-economic background of the child to have a significant effect on the adequacy of his verbal justification of matrix responses. Only 25% of the culturally deprived children who succeeded on the matrix task could adequately justify their responses, while all the middle class children could do so. From these investigations, it would appear that culture, socio-economic background, and the type of stimuli used, have an effect on the child's ability to adequately justify his behavioural response.

In the present investigation, culture, socio-economic level and IQ of the subjects were controlled, making it possible to investigate the relationship between sex, age, stimulus and task variables and the adequacy of the subjects' verbal justifications of behavioural responses. It must be noted that these variables have not been extensively examined in the previous literature.

Sex relationships in the adequacy/inadequacy of verbal justifications were observed in only three of the eight analyses (Table 81). These findings have been rather inconsistent. The older females adequately justified their free classification responses using 3-D stimuli more frequently than did the males (Table 64). This relationship was not observed among the younger subjects. Nor was it observed among both age groups, using 2-D stimuli. The younger males adequately justified their matrix responses, using 2-D stimuli, more frequently than did the females (Table 65). In contrast, the older females adequately justified their matrix responses, using 2-D stimuli, more frequently than did the males (Table 66). Of the three significant relationships observed, two revealed that the females were giving a greater frequency of adequate verbal justifications. While this may be seen as providing support for the conventional sex stereotype with regard to verbal ability, namely that females generally have an advantage over males in language development and verbal ability, it would perhaps, be more reasonable to regard these findings as being due to chance. The results have been rather inconsistent to make any convincing generalizations.

Significant relationships between age and the adequacy/inadequacy of verbal justifications were observed in two of the four analyses (See Table 81). On the free classification task using 2-D stimuli, the younger subjects adequately justified their responses more frequently than did the older subjects (Table 69). Alternatively, the older subjects gave more inadequate justifications than did the younger subjects. A possible explanation for this could be that since the younger subjects gave more unidimensional behavioural responses, they therefore found this type of behavioural response easier to justify. On the other hand, the older subjects gave more multi-dimensional behavioural responses but justified these without reference to all the relevant attributes utilised in their behavioural response.

The above is strengthened by the findings on the adequacy of the verbal justifications given on the matrix tasks using 3-D stimuli (Table 70). The older subjects did better than the younger subjects. While this relationship was not significant with the 2-D stimuli, the trend was still there (Table 71). In the matrix task where only two attributes of the stimuli were involved with the third attribute being kept constant, unlike the multi-dimensional responses on the free classification task where three attributes could be used, the older subjects gave adequate verbal justifications more frequently than did the younger subjects.

Significant relationships between the stimulus variable and the adequacy of the verbal justifications were observed in two of the four analyses. The older subjects did better with the 3-D stimuli than with the 2-D stimuli on both the free classification (Table 74) and matrix (Table 76) tasks. No such relationships were observed among the younger subjects. These findings suggest that the older subjects find the 3-D stimuli simpler and can explain their behaviour more easily, with their greater experience and proficiency in language. This could possibly explain why the younger subjects did not do as well. If these results are viewed in conjunction with the findings with respect to the age variable, a possible age x stimulus interaction is suggested.

The task variable was found to be significantly related to the adequacy of verbal justifications of the older subjects on both 2-D (Table 79) and 3-D (Table 80) stimuli. In both instances, the older subjects found it easier to justify their matrix responses. The same trend was noted with respect to the behavioural responses, where it was reported that subjects found the matrix tasks easier than the free classification task (See Chapter Eight). No significant relationships were observed between the task variable and the verbal justifications of the younger subjects. A possible explanation for this may be that, by virtue of the structured nature of the matrix task, where only two stimulus attributes are involved, the older child can perceive the correctness of his behavioural response. He, therefore, feels more confident in explaining what he has done. It must be remembered that in the matrix task, the pattern of similarity in the vertical and horizontal directions was determined by the experimenter who filled in some of the cells as a starter. The subject who succeeded on the matrix task obviously recognised the patterns of similarity. His verbal justification was, therefore, a description of part of the experimenter's behaviour and part of his own.

The fact that the younger subjects did not pick up the available cues in justifying a response that was behaviourally correct, does suggest that their linguistic and cognitive proficiencies are not parallel.

As far as the free classification task was concerned, apart from the number of stimulus attributes utilised in the behavioural response as stated above, the task offered no cue as to the acceptability of the subject's response. The child had no way of knowing whether the response he gave was the one he ought to have given. This uncertainty perhaps inhibited an adequate verbal justification.

The comparatively high proportion of inadequate justifications given by the older subjects on the free classification task needs comment. The findings could be a function of the way in which the free classification behavioural and verbal responses were scored. The technique adopted in this study requires closer scrutiny. By taking all the "successful" free classification responses, the uni-dimensional responses were equated with the multi-dimensional responses. Obviously, a uni-dimensional response, where a single attribute (e.g., colour, shape, or size) is involved, is easier to justify verbally than is a multi-dimensional response where several stimulus attributes are simultaneously involved. It was reported in Chapter Six that the younger subjects gave more uni-dimensional than multi-dimensional free classification behavioural responses. The reported age discrepancy in the adequacy of verbal justifications may, therefore, to some extent be limited to the particular scoring procedure adopted in this study. Different scoring techniques may help to clarify the relationship between behavioural responses and the adequacy of verbal justifications. Further attention on the inadequate verbal justifications may also prove helpful.

CHAPTER TEN

SUMMARY AND CONCLUSIONS

10.1 INTRODUCTION

The results already presented and discussed in Chapters Six, Seven, Eight, and Nine will be briefly summarised and an attempt made to draw some general conclusions. Most of the points and issues raised by this research have already been discussed in the relevant chapters. For ease of reference, the findings from the different chapters are treated separately.

10.2 FREE CLASSIFICATION ABILITY

The results of the investigation into the free classification behaviour of the subjects have been presented in Chapter Six. The main finding was that the older subjects gave significantly more multi-dimensional responses on the first free classification trial, using both 2-D and 3-D stimuli, than did the younger subjects. These results were obtained through the nonparametric chi-square analysis (Table 30, p. 111). The analysis of variance also showed that the age variable was significant beyond the 0,01 level (Table 31, p. 118).

The sex and stimulus variables were found to be not significant. Nor were there significant differences in the responses of the subjects across the three free classification trials except for the responses of the younger subjects on 3-D stimuli. In this instance, the younger subjects showed a steady decline in the number of simple, uni-dimensional responses from the first to the third trial, and a progressive increase in the number of complex, multi-dimensional responses (Table 25, p. 107). However, this finding was not observed among the older subjects and among the younger subjects themselves, using 2-D stimuli (See Table 30, p. 111).

The only variable, then, which consistently influenced the subject's free classification behavioural responses, was age. By age 12, more of the subjects are paying attention simultaneously to more than one attribute of the stimuli, than is the case with the younger, 9 year old subjects. The younger subjects concentrate more on one attribute at a time. This is as Piaget (Inhelder and Piaget, 1964) predicted. The fact that some of the 9 year olds did give multi-dimensional responses may be seen as a reflection of individual differences in cognitive development.

The results indicate that as far as the sequence of acquisition of free classification behaviour is concerned, the Indian child appears to be no different from the Genevan or American child. However, the Indian child does show an age lag in the appearance of free classification behaviour. Piaget (Inhelder and Piaget, 1964) states that true or hierarchical classification ability is acquired between the ages of 7 to 11 years. In the present investigation the majority of the 9 year olds had still not reached this stage. However, notwithstanding the difficulty in making direct comparisons with the evidence reported among the "primitive" cultures (e.g., Price-Williams, 1962), because of variations in sample characteristics, methodology, and choice of stimuli, it does appear that the Indian child is ahead of the children from these "primitive" cultures in terms of the age at which classification ability is manifested.

The absence of significant sex differences in free classification behaviour is consistent with previous investigations. No study reviewed reported significant sex differences. The reason why the sex factor was isolated in the present study was to eliminate the possibility of it influencing the dependent variable in some subtle way.

The findings with respect to the stimulus variable may appear contradictory. In the present investigation there was no significant relationship between the type of stimuli and free classification behaviour. Previous studies (Price-Williams, 1962; Irwin and McLaughlin, 1970) report that familiar stimuli facilitate free classification behaviour. One possible explanation for the apparent contradiction may be related to the age of the subjects. Dassen's (1967) formulation states that as age increases, the situational and cultural variables play a lesser role in classification behaviour. In the present investigation, the younger subjects were 9 years old, came from a middle-class background and occupied the top ten positions in their classes. These children had probably reached the age at which, in terms of Dassen's (1967) equation, the influence of the situational variables is no longer an important factor. This issue can be clarified by including children younger than 9 years old in the sample.

Another possible explanation may be related to the stimuli themselves. It must be remembered that the concept of familiarity of stimuli is very relative. Previous investigators (e.g., Irwin and McLaughlin, 1970) have, in their attempt to elicit some positive response from traditionally "primitive" subjects, utilized stimuli that their subjects had experienced. These have been far too specific to individual cultures to permit external validation of their findings. In the present investigation, the 2-D and 3-D stimuli were drawn from the same domain and one set was the exact equivalent of the other in terms of shape, size, and colour. The only difference was that one set was made up of plane figures while the other was constructed in three dimensions. The basis for regarding the 3-D set as more familiar was that they appered as balls and building blocks which all children have handled from an early age. Even if some "primitive" children have not actually played with factory produced balls and building blocks, it is hard to imagine any society in which the children have not handled spherical, cuboidal and prism-shaped objects. The stimuli used in the present investigation, therefore, allows for external validation across cultures. They also provide scope for examining the familiarity issue as well as the dimensionality issue. However, the familiarity issue seems a major problem in cross-cultural research as it is very difficult to determine what is familiar and to measure the level of familiarity.

The reclassification factor was not significant except in one analysis only. The age, sex, and stimulus variables had no effect on the "successful" reclassification responses of subjects. The older subjects did not reveal any change in the dimensionality of their responses across the three trials with each set of stimuli. The younger subjects, however, showed a progressive increase in the number of complex, multi-dimensional responses from the first to the third trial, using 3-D stimuli, but not with 2-D stimuli (See Table 30, p. 111).

It seems then, that when success is taken as the response measure, without regard for the dimensionality of the response, all the subjects, regardless of age or sex, reclassify both sets of stimuli equally well. When the dimensionality of response is taken into account, the younger subjects show an improvement on successive trials, using 3-D stimuli. These results underline the need for a standardized system of scoring free classification behavioural responses when multi-attributed stimuli are used.

The fact that the children could and did reclassify the stimuli when requested to do so, suggests that their first response was one of preference. Cole and Scribner (1974), basing their argument on the findings among Yucatan subjects and studies in Senegal, suggest that perhaps classification and reclassification are not necessarily the result of the same process. The data they assessed revealed that many subjects who could make an initial classification response, could not reclassify the stimuli along another dimension. Their results could be due to the specific dimensions of the stimuli and the methodology employed. In the present research, subjects did reclassify the stimuli, suggesting that classification and reclassification behaviour develop parallely. However, the reclassification responses were generally of the same cognitive level as the initial response. Except for the one instance mentioned above, subjects tended to make the same kind of response across all three trials.

10.3 MATRIX CLASSIFICATION ABILITY

The results of the investigation into the matrix classification behavioural responses are presented in Chapter Seven. The age factor was found to consistently influence success on the matrix tasks. The older subjects consistently succeeded more often than did the younger subjects, regardless of whether 2-D or 3-D stimuli were used or whether success was measured after three or five prompts (See Summary Table 45, p. 132).

A possible reason why the older subjects succeed more often than do the younger subjects could be that by age 12 years, they attend to two attributes of the stimuli, while the majority of the younger 9 year old subjects do not. This is borne out by the findings with respect to free classification behaviour already stated above. Piaget (Inhelder and Piaget, 1964) and Bruner (1967) state that matrix classification behaviour only appears when the child can simultaneously attend to two attributes of the stimuli.

Although the older subjects succeeded on the matrix tasks more often than did the younger subjects, even the younger subjects showed a high rate of success. After five prompts, 58% of the 9 year old subjects' matrix responses were correct, using 2-D stimuli (Table 43, p. 130) and 59% were correct using 3-D stimuli (Table 44, p. 130). This suggests that around 9 years of age, over half the subjects have already advanced from the pre-operational to the concrete operational stage. The remaining subjects are still functioning at the pre-operational level in this aspect. It would appear that for the subjects in the present investigation, 9 years of age seems to mark the period of transition from centration to decentration, from static to dynamic thought and from irreversible to reversible thinking. Again, a lag of about two years in comparison with Genevan children is noted.

The relationship between the type of stimulus used and success on the matrix tasks was found to be inconsistent as revealed by the chi-square analyses (see Summary Table 45, p. 132). The younger subjects showed no difference between 2-D and 3-D stimuli, while the older subjects did better with 3-D stimuli than with 2-D stimuli.

On the other hand, the analysis of variance revealed the stimulus factor to be significant (See Table 46, p. 138), suggesting that the stimulus factor does affect success on the matrix task. The pooling of the responses of all the subjects in the analysis of variance may have been responsible for the stimulus variable being significant. It must be remembered that, in terms of Dassen's (1977) formulation, it is precisely during this transitional stage that the situational variables (in this instance, the stimuli) have a maximum influence on success.

The significant age x sex x stimuli interaction is interesting. The sex factor by itself was consistently found to be not significant. However, when taken in combination with the age and stimulus factors, it does have an effect. The males and females of each age group do not succeed to the same extent with both types of stimuli.

The relative difficulty of the three matrix trials (colour x shape, colour x size, and shape x size) was also investigated. It was found that there was no significant difference between the three tasks (See Table 45, p. 132), using both 2-D and 3-D stimuli. Measuring success after three prompts or after five prompts also did not affect the findings. These results suggest that any one of the three trials adequately assesses matrix ability. Re-classification does not provide any new information. Nor does success appear to progressively increase with the number of prompts.

10.4 COMPARISON OF FREE AND MATRIX CLASSIFICATION ABILITY

The free classification and matrix responses of the subjects were compared in Chapter Eight. For the chi-square analyses the responses of subjects on the first trial of each task were taken as the response measure. It was found that, except for the older subjects using 2-D stimuli (Table 52, p. 147), the subjects who gave multi-dimensional free classification responses also succeeded on the matrix task. Subjects who gave uni-dimensional free classification responses generally failed on the matrix task. It was also found that subjects solved the matrix problem more frequently than they gave multi-dimensional free classification responses. These results were supported by the analysis of variance. The task variable was found to be significant. The subjects found the matrix task easier than the free classification task (See Table 54, p. 152).

These results appear to contradict the formulations of Piaget (Inhelder and Piaget, 1964) and Bruner (1967), both of whom imply that the ability to give a multi-dimensional free classification response may be a pre-requisite for success on the matrix task. It could be that the two tasks are not necessarily the result of the same cognitive process. Or, conversely, the results may be a function of the unique combination of the age of subjects, the stimuli used, the methodology used in the free classification tasks, and the particular scoring techniques adopted in this investigation. The need for a standardized system of scoring responses is again indicated.

The results of the analysis of behavioural responses of the subjects may be summarized as follows. Older subjects gave more multi-dimensional free classification responses than did younger subjects. Older subjects also succeeded on the matrix tasks more frequently than did younger subjects. Subjects found the 3-D stimuli easier than the 2-D stimuli when solving matrix problems but found both of equal difficulty when free classifying. Subjects found it easier to solve the matrix task than to give a multi-dimensional free classification response. The sex variable was consistently found to be not significant but cannot be ignored as it may be interacting with other variables to modify the results.

10.5 VERBAL RESPONSES

The main aim behind investigating verbal responses was to see whether there were any discrepancies between verbal and behavioural responses. Could subjects adequately explain their behavioural responses, or were their behavioural responses functioning at a higher or lower cognitive level than their verbal responses?

The results have been somewhat inconsistent (See Summary Table 81, p. 177). Significant sex relationships were observed in only three of the eight analyses. Of these, two analyses revealed that the females adequately justified their responses more frequently than the males. This was observed among the older subjects on the free classification tasks with 3-D stimuli and on the matrix task with 2-D stimuli. The third significant result revealed the opposite trend. The younger males adequately justified their matrix responses, using 2-D stimuli, more frequently than did the females. It would appear that the significant findings could be due to chance, particularly as the direction of difference was also inconsistent. It may therefore, be concluded that the sex variable is not significantly related to the adequacy of the subjects' verbal justifications of their behavioural responses in any consistent manner.

The age factor was found to be significantly related to the adequacy of verbal justifications in two of the four analyses (See Summary Table 81, p. 177). The younger subjects adequately justified their free classification behavioural responses, using 2-D stimuli, more frequently than did the older subjects. On the matrix task, using 3-D stimuli, the older subjects did better than the younger subjects. These results have been discussed in Chapter Nine. The younger subjects gave predominantly uni-dimensional free classification behavioural responses which were obviously easier to justify. On the matrix task, where the behaviour had to be explained in terms of the two attributes manipulated as well as the third attribute which was kept constant, the older subjects, with their greater experience and proficiency in language, did better than the younger subjects.

The stimulus factor was found to have no relationship to the adequacy of verbal justifications given by younger subjects on both the free classification and matrix tasks. However, the older subjects gave more adequate responses with 3-D stimuli than with 2-D stimuli on both the free classification and matrix tasks (See Summary Table 81, p. 177). These results suggest that the older subjects find it easier to justify their responses when working with 3-D stimuli. However, it must be noted that the results are to some extent limited to the specific instructions, methodology and verbal response scoring procedure adopted in this investigation.

The younger subjects revealed no differences in the adequacy of their justifications between the free classification and matrix tasks. However, the older subjects found it easier to adequately justify their matrix responses on both 2-D and 3-D stimuli. This suggests that the older subjects, with their greater experience and fluency in language, still find the free classification behavioural responses more difficult to explain adequately. Obviously, the explanation in terms of the number of attributes used, no longer applies as the matrix task requires attention to all relevant attributes. It would appear that the matrix task does provide perceptually concrete cues as to the correctness of the response which the older subject, by virtue of his superior language ability, is better able to articulate.

The overall results of the verbal justifications of behaviour lead to the conclusion that children tend to manifest classification ability more readily through behavioural responses than through verbal explanations. This is supported by the evidence that in every analysis some subjects failed to adequately explain a behavioural response which in itself indicated the presence of classification ability. The results support Bruner's (1967) argument that cognitive reordering and restructuring occurs independently of language ability. Hence his emphasis that what children do with the stimuli, rather than what they say about them, should constitute the primary data for assessing classification ability. If the Piagetian technique (Inhelder and Piaget, 1964) is adopted, all those children who did not adequately explain their behaviour would be regarded as not having attained classification ability. This procedure would not distinguish between the ability to classify and that of verbal and language fluency. However, it is quite possible that if the experimenter had pursued the probing technique as used by Piaget (Inhelder and Piaget, 1964) the children may eventually have given adequate explanations.

Another point that needs mentioning is that the subjects were drawn from the top ten pupils in each class and came from middle-class homes. Obviously, these children were more likely to have acquired a greater level of language fluency than the general school population or children from lower class homes. If so many of the subjects in the sample failed to adequately justify their behavioural responses, it can be reasonably assumed that the situation would be much worse among the general school population. This raises some doubts as to the efficacy of the traditional school instructional and assessment technique, which are heavily language orientated. Perhaps, a technique emphasizing more activity, at least until the age of 12, would be more beneficial. For example, the teaching of mathematics may be improved if subjects are made to manipulate objects and to establish relationships among them, as is the case in infant teaching. Biology may be more effectively taught by actually handling and sorting specimens, and visits to gardens and zoos or museums than by formal disseminaton of verbal information in a classroom. While these techniques are applied, perhaps a greater emphasis on them may be found to be useful.

10.6 PRACTICAL PROBLEMS

A pilot study in which the experimental design and methodology were tested out, helped to a great extent in ensuring that hardly any serious practical problems were encountered when the research proper was in progress. Some of the problems encountered were beyond the control of the researcher. One of these was the non-availability of a testing venue in some schools. While a venue was promptly made available in every school, these included evacuated classrooms and offices or the school library. This variation in venues at the different schools could have affected performance, expecially when an office was used for the first session, as children appeared somewhat apprehensive when "summoned to the office". This apprehension was allayed by the second session, as by then the children were aware of the nature of the "testing".

Another problem that could not be controlled was the amount of time individual subjects took over the tasks. While the average time taken was about 25 minutes per session, some children took about 15 to 20 minutes on some individual tasks. Perhaps, it would be more practical to introduce some standardized time limit on each task.

Some of the problems could be resolved in future studies. One of these is the order of presentation of the free classification and matrix tasks. It was stated in Chapter Eight that the superior performance on the matrix task could have been, to some extent, attributed to practice effects from the free classification task, which always preceeded the matrix task. This order was followed because of the theoretical viewpoint that free classification behaviour is manifested before matrix classification behaviour. A random variation in the order of presentation will help to neutralise any possible practice effect. A series of studies giving attention to the above considerations are currently in progress.

10.7 PRACTICAL AND THEORETICAL IMPLICATIONS

The practical value of this research derives primarily from the unique experimental design and methodology adopted. For the first time an attempt was made to compare free and matrix classification responses within the same individuals using the same set of stimuli. In the past, attempts have been made to make generalizations from comparatively disjointed studies, which have varied widely in experimental procedures, age of subjects, choice of stimuli, and scoring of responses, thus allowing little scope for external validation of results.

The findings from the present investigation make useful contributions to both the theoretical and methodological issues in cognitive development in general and classification ability in particular. These have been mentioned in the relevant places in the four chapters dealing with the results.

The need for the selection of stimuli that allows for cross-cultural validation have already been mentioned. The stimuli used in the present investigation can be used across a wide variety of cultures.

The experimental design, adopted, which was essentially a 2 x 2 x 2 x 2 (sex x age x type of stimuli x task) factorial design with repeated measures on the last two factors, appears to be a more suitable design applicable in this field than the traditional designs used by many previous investigators.

The procedure of scoring the data and the nonparametric and parametric analyses techniques should also prove useful to future researchers in this area. Obviously, results that are coroborated by both techniques are far more convincing than results obtained by only one of the techniques.

Theoretically, one of the major findings relates to the conventional assumption that free classification and matrix classification ability should appear as a continuum in that fixed sequence. The results of this study suggests that the two may not be the result of the same cognitive structures and operations. Or, it could be that the traditional instructions given in respect of the free classification task and the task itself need reappraising. These issues need to be further investigated.

Another finding of theoretical relevance concerns the discrepancy between the level of behavioural responses and verbal explanations. This suggests that the traditional Piagetian (Inhelder and Piaget, 1964) technique of diagnosing level of cognitive development needs close attention. In cultures where the formal use of language is dependent upon school experience, reliance on verbal explanations may give an inaccurate picture of the level of cognitive development of the child.

The lag (of about two years) in cognitive development of the Indian child as compared to Genevan and American children reported in this study has important implications. The factors that contribute to this lag and effective remedial measures need to be identified.

In general, this study provides a reasonably standardized design and methodology that may be used to further extend the field. Its contribution to cross-cultural cognitive research is another important aspect.

10.8 FUTURE RESEARCH POSSIBILITIES

Several possibilities for future research in the field of classification ability emerge from this investigation. These involve both methodological and theoretical considerations.

The methodology may be improved with more standardized instructions. It was stated in Chapter Eight that the instructions used tended to favour matrix classification behaviour. Perhaps different instructions may be used and their effects investigated.

The size of the matrix and its symmetry may be varied and the effect of such variation examined.

The stimuli used in the present investigation was more culture-free than those used by many previous researchers in the field. Perhaps other stimuli may be developed using a different domain, but sharing the salient characteristics of the stimuli used in this study.

The findings reported in this investigation are limited to the age group studied. Inclusion of children of lower ages should provide additional information and may help to resolve some of the issues raised, particularly in those instances where the age variable appeared to have no effect, e.g., reclassification ability.

Further research is also needed to standardize scoring procedures. It was mentioned that the results may be limited to the specific scoring procedure used in this investigation. Other scoring procedures may possibly produce different results. Ultimately, a standard scoring procedure may have to be evolved. Only then will external validation of studies become possible.

The effect of the order of presentation of the tasks also needs investigation. It is not known to what extent practice effects from the free classification task influenced performance on the matrix task.

The relationship between free and matrix classification ability needs further research. The evidence from this study suggests that the two may be a result of different cognitive structures and operations. This needs to be examined in different cultures through different methods.

The relationship between behavioural classification responses and verbal justifications need further examination. Factors that may possibly affect this relationship need to be identified. Will stimulus attributes other than shape, colour, and size, help to improve verbal explanations? Also, there must be some age at which children are able to adequately justify their behavioural responses. These issues need to be further investigated.

The above are only some of the possibilities that emerge from the present investigation. Much research still needs to be done to answer that many unanswered questions in this vitally important area of classification development.

CHAPTER ELEVEN

SUMMARY

This study was undertaken for the purpose of obtaining some knowledge about the problems and issues that surround the classification ability of children.

Current research in the area appears to be disjointed in terms of the variations in age of subjects tested, experimental procedures employed, stimuli selected, scoring techniques used and the theoretical foci adopted. This has made external validation of studies and cross-cultural generalizations extremely difficult.

This study was designed to examine the relationship between age, sex, type of stimuli, and task variables on classification behavioural and verbal responses of Indian children. The aims of the investigation were:

(a) To examine the developmental changes in free and matrix classification ability among younger and older Indian children.

(b) To investigate differences, if any, in performance using 2-D and 3-D stimuli.

(c) To investigate differences, if any, between free and matrix classification tasks.

(d) To investigate the preference versus ability issue by examining reclassification behaviour in free and matrix classification tasks.

(e) To examine the relationship between behavioural responses and appropriate verbal justifications of such responses.

(f) To provide continuity and cross-cultural generality to much previous investigations in the area.

The subjects comprised 30 boys and 30 girls from each of two age groups, namely, 9 year olds (younger) and 12 year olds (older), giving a total of 120 subjects. Each child came from the top ten in his respective class and from a middle-class home.

The stimuli were drawn from a mathematical domain. The 2-D geometric stimuli varied in shape (circle, square, triangle), colour (blue, green, red), and size (small, medium, large), and were cut from three-millimetre thick hardboard. The 3-D stimuli were exact equivalents of the 2-D set, but were constructed in three dimensions, giving spheres, cubes, and triangular prisms.

Each child was tested individually over two sessions, during one of which the 2-D stimuli were used and during the other, the 3-D stimuli were used. The order was randomly varied. At each session, three free classification trials were given first followed by the matrix trials. After each behavioural response, the child was asked to verbally justify his response.

The data were analysed through both the nonparametric chi-square and the parametric analysis of variance techniques.

The chi-square analysis of behavioural responses revealed the following:

(a) Older subjects gave more multi-dimensional free classification responses than did younger subjects.

(b) Older subjects succeeded on the matrix task more frequently than did younger subjects.

(c) Subjects of both ages found the matrix task easier than the free classification task.

(d) Subjects found the 3-D stimuli easier to work with when solving matrix problems but the stimulus variable was not significantly related to free classification responses.

(e) The sex variable was consistently found to have no relationship with behavioural responses.

The analysis of variance data essentially supported the above findings.

The chi-square analysis of verbal responses yielded inconsistent results, making generalization difficult.

The results suggest that certain methodological and theoretical issues need further investigation. The need for a standardized methodology and scoring technique has already been emphasized. The relationship between free and matrix classification ability, and between behavioural and verbal responses also needs scrutiny.

The investigation employed stimuli that could allow for external validation of the findings across a wide variety of cultures, and with appropriate modification and standardization of instructions and scoring, these could prove very useful in future investigations.

APPENDIX A

TEACHER'S QUESTIONNAIRE

The Class Teacher

With the kind permission of the Department of Indian Education, a psychological investigation is being conducted in certain Indian schools. Your Principal has consented that this school should participate.

In order to select an appropriate sample of pupils from this school certain information is required from you. Please complete the questionnaire below and return it to your Principal as soon as possible.

Thank you.

R D RAMKISSOON
Department of Psychology
University of Durban-Westville

SCHOOL .... Standard .... Room No. .....

List the names of the top ten pupils in class, on the basis of school performance up to the third quarter of this year. Next to each name, please provide the additional information required.

	N A M E	SEX	DATE OF BIRTH	S E S*
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

*****Please estimate the socio-economic status of each child on the basis of your knowledge of the child's home, his parents' occupation, etc. Classify each child as either high, middle, or low, according to your opinion. If you cannot decide on any one child put a question mark in this column next to his/her name.*

....
CLASS TEACHER

APPENDIX B

RESPONSE SHEET

CLASSIFICATION BEHAVIOUR

NAME: ______ SEX: ______ CLASS: ______

DATE OF BIRTH: ______ AGE: ______ DATE OF TEST: ______

SESSION: ______ CODE: ______

A. FREE CLASSIFICATION RESPONSES STIMULI: 2-D / 3-D

TRIAL 1

Response : ______

Reason : ______

TRIAL 2

Response : ______

Reason : ______

TRIAL 3

Response : ______

Reason : ______

B. MATRIX CLASSIFICATION RESPONSES

TRIAL 1 : COLOUR BY SHAPE

SIZE USED: ____________

(i)

1 RT/RP	2	3
4	5 GC/ GSp	6
7	8	9 BSq/ B/Cu

Reason : ______________________________

(ii)

1 RT/RP	2	3
4	5 GC/ GSp	6
7 BT/ BP	8	9 BSq/ B/Cu

Reason : ______________________________

(iii)

1 RT/ RP	2	3 RSq/ B/Cu
4	5 GC/ GSp	6
7 BT/ BP	8	9 BSq/ B/Cu

Reason : ______________________________

KEY :

RT : Red Triangle
RP : Red Prism
RSq : Red Square
RCu : Red Cube
GC : Green Circle

GSp : Green Sphere
BT : Blue Triangle
BP : Blue Prism
BSq : Blue Square
BCu : Blue Cube

TRIAL 2 : COLOUR BY SHAPE

SHAPE USED:

(i)

1 BL	2	3
4	5 GM	6
7	8	9 R Sm

Reason :

(ii)

1 BL	2	3
4	5 GM	6
7 R Sm	8	9 R Sm

Reason :

(iii)

1 BL	2	3 RL
4	5 GM	6
7 B Sm	8	9 R Sm

Reason :

KEY :

BL : Blue Large
RL : Red Large
GM : Green Medium
B Sm : Blue Small
R Sm : Red Small

TRIAL 3 : SHAPE BY SIZE COLOUR USED: ______________

(i)

1 TL/ PL	2	3
4	5 CM/ Sp M	6
7	8	9 SqSm Cu Sm

Reason : ______________

(ii)

1 TL/ PL	2	3
4	5 CM/ Sp M	6
7 Sq L/ Cu L	8	9 SqSm/ CuSm

Reason : ______________

(iii)

1 TL/ PL	2	3 T/Sm P Sm
4	5 CM/ Sp M	6
7 Sq L/ Cu L	8	9 SqSm Cu Sm

Reason : ______________

KEY :

TL	:	Triangle, Large	Sp M	:	Sphere, Medium
PL	:	Prism, Large	Sq L.	:	Square, Large
TSm	:	Triangle, Small	Cu L	:	Cube, Large
PSm	:	Prism, Small	Sq.Sm	:	Square, Small
CM	:	Circle, Medium	Cu Sm	:	Cube, Small

APPENDIX C

RAW DATA : BEHAVIOURAL AND VERBAL RESPONSES

For convenience of tabulation the raw data are presented in a codified form. The behavioural responses have been coded into digits. These digits are *not the scores* used in the quantitative analyses but merely represent a specific type of response. The verbal justifications have been coded +(adequate) and -(inadequate). All behavioural responses coded zero (0) were unsuccessful responses and were not considered when scoring verbal justifications. The codes used are listed below.

A FREE CLASSIFICATION BEHAVIOURAL RESPONSES

0 = Unsuccessful

1 = Colour

2 = Shape

3 = Size

4 = Colour x Shape

5 = Colour x Size

6 = Shape x Size

7 = Colour x Shape x Size Seriated

B MATRIX BEHAVIOURAL RESPONSES

0 = Unsuccessful

1 = Successful : Three Prompts

2 = Successful : Four Prompts

3 = Successful : Five Prompts

C VERBAL RESPONSES

\+ = Adequate verbal justification of behavioural response

\- = Inadequate verbal justification of behavioural response

1. RESPONSES OF YOUNGER MALES (N = 30)

SERIAL NUMBER	FREE CLASSIFICATION						MATRIX					
	2-D STIMULI			3-D STIMULI			2-D STIMULI			3-D STIMULI		
	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAl 2
004	0	1+	0	2+	0	0	0	0	0	0	0	0
007	6-	1+	3+	2+	1+	6+	3+	2-	1+	0	0	1-
048	1+	2+	2-	2+	2+	2-	0	0	0	0	0	0
044	2+	1+	2+	2+	2+	4-	0	0	3-	0	0	0
037	2+	1+	2+	4+	6+	0	0	2+	1+	1+	1+	1+
023	4-	1-	4-	6+	2+	6-	0	2+	3+	3+	1+	0
008	6+	7+	0	2+	2-	2-	0	2+	3+	1+	1+	1+
013	6-	0	0	0	2-	2-	0	0	2-	0	0	0
014	1+	0	2+	4-	4-	0	0	3+	1+	0	2-	1-
018	6-	5-	6-	4-	6-	5-	0	3-	0	3+	2+	0
017	2+	0	2+	2+	0	0	0	0	0	0	0	0
016	6-	0	0	4-	6-	6-	0	0	0	0	3+	0
015	2-	0	0	2-	0	6-	0	0	0	0	0	0
136	0	0	2+	2+	0	2+	0	0	0	0	0	0
135	6+	6-	6-	6-	6-	6-	3+	1+	0	1+	2+	2-
129	2+	6-	6-	2+	6-	6-	1+	1+	1+	1-	1+	1+
130	2+	2+	2+	2+	2+	2+	3+	1+	1+	0	1+	2-
127	2+	2+	2+	6-	6-	6-	1+	1+	0	1+	1-	1+
128	2+	1+	2+	2+	0	2+	0	0	1-	3+	1+	1-
132	2+	1+	2+	2+	2+	2-	2+	1+	1+	0	2+	1+
131	4-	1+	4-	2+	2+	1+	3+	2+	1+	0	1+	2-
005	4+	2+	6-	4+	1+	0	0	1+	1+	0	2+	1-
100	6-	1+	6-	6-	1+	0	3+	1-	1-	3+	0	3-
102	2+	6-	6+	2+	6-	6-	1+	1-	2-	1+	1+3+	
110	6-	6-	0	6-	6-	6-	1+	1-	1-	2+	1-	2+
109	6-	2+	6-	2+	2+	6-	2+	1-	1-	1+	2+	1-
137	6-	1+	3+	2+	4+	6-	1+	1+	1+	1+	2+	2+
138	2+	2+	1+	2+	2+	1+	3+	1+	2+	3+	2-	1+
139	1+	1+	2+	4+	4-	1+	3+	1-	1-	0	1-	0
140	2+	1+	2+	1+	2+	2+	1+	1+	1+	2+	1+	1+

2. RESPONSES OF YOUNGER FEMALES (N = 30)

SERIAL NUMBER	FREE CLASSIFICATION						MATRIX					
	2-D STIMULI			3-D STIMULI			2-D STIMULI			3-D STIMULI		
	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIA 3
133	2+	2+	2+	2+	2+	2+	0	0	0	0	2-	2-
122	6-	2+	6-	2+	6-	6-	1+	1-	1+	1+	1-	1-
121	2+	2+	1+	2+	1+	6-	1+	1+	1+	1+	1+	1+
123	1+	2+	3+	2+	6-	2+	1+	2-	3+	2+	2+	1-
124	1+	4-	0	2+	2+	1+	0	0	0	0	0	1+
125	2+	1+	3+	2+	0	6-	1+	1+	1+	2+	1+	1-
126	2+	2+	6-	4-	6-	6-	2+	0	0	2-	1+	1+
104	2+	2+	2+	2+	2+	2+	0	0	0	0	1-	0
105	2+	2+	0	2+	2+	2+	3+	1-	1-	0	0	0
106	6+	1+	6+	2+	4-	6-	0	1-	1-	0	1+	1+
107	2+	2+	1+	1+	2+	1+	0	2-	1-	0	1+	1-
108	6-	1+	3+	2+	4+	6-	1+	1+	1+	1+	2+	2+
111	2+	2-	1+	2+	2+	1+	3+	1+	2+	3+	3-	1-
103	4+	4-	4-	4+	4-	1-	3+	1-	1-	0	1-	0
101	2+	1+	2+	0	1+	0	2+	1+	1+	0	2+	2+
012	2-	2+	0	2+	2+	0	2+	0	0	3+	0	3+
011	2+	1+	3+	1+	3+	2+	2+	2+	2+	1+	2+	1+
014	1+	4-	0	1+	6-	0	0	0	0	0	0	0
009	2+	0	1+	2+	2+	1+	0	0	0	0	0	0
001	6-	6-	6-	6-	6-	6-	0	1-	0	1+	2+	0
047	1+	2+	3-	1+	2+	2+	1+	2+	3+	3+	1+	0
046	2-	2-	4+	2-	2+	2+	0	0	0	0	0	0
045	6-	6-	6-	2+	6+	6-	1+	1-	1+	1+	1-	1-
043	0	0	2-	2-	0	2+	0	0	0	0	0	0
042	2+	2-	6-	2-	2+	6-	0	0	0	3+	3+	1-
041	1+	2+	3-	2+	1+	0	0	0	0	0	0	0
040	0	0	0	2+	2-	0	0	0	0	0	0	0
039	2+	1+	0	1+	2+	0	0	0	0	0	0	0
038	2+	2+	2+	2+	4-	4+	3+	1+	3-	3+	0	1+
134	2+	2-	2-	2+	4-	6-	3+	1-	1-	0	1+	1+

3. RESPONSES OF OLDER MALES (N = 30)

SERIAL NUMBER	FREE CLASSIFICATION						MATRIX					
	2-D STIMULI			3-D STIMULI			2-D STIMULI			3-D STIMULI		
	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRI 3
086	2+	0	1+	2+	1+	6+	0	3+	1-	1+	1+	1
085	6-	6-	3+	6-	2+	4-	0	0	0	1+	1-	1
084	2+	1+	1+	2+	1+	6-	0	1-	1+	1+	1+	1
082	6+	2+	2+	6-	1+	6+	3+	1-	1+	2+	3+	3
051	6-	7+	7+	6-	6-	6-	1+	1+	3+	1+	1+	3
050	5+	2+	6-	5+	6-	4+	2+	1+	2+	1+	1+	2
049	6-	6-	1+	4+	2+	1+	0	2+	1+	2+	1-	2
033	6-	2-	6-	6-	6-	1+	2+	1+	0	1+	1+	0
029	4+	4+	1-	2+	4-	2+	2+	1+	1+	0	1+	1
021	4+	6+	2+	4+	6+	2+	1+	1+	2+	2+	1+	1
020	2+	1+	6+	1+	2+	6-	0	2+	2+	2+	1+	2
022	2+	2+	2-	2+	1+	0	0	0	0	0	2+	2
025	2+	1+	6-	2+	1+	6-	1+	1+	3+	1+	1+	1+
027	6+	2+	6-	4-	4+	6+	0	1+	2+	0	1+	3+
120	1+	2+	2+	2+	2+	1+	1+	1+	1-	2+	1-	1-
078	6-	6-	1+	6-	4+	6-	1+	1-	2+	2+	3+	3-
119	2+	3+	1-	2+	1+	6+	1+	1+	1-	1+	1+	1+
118	2-	2+	6+	6+	2+	2-	1+	1+	2-	3+	1+	1+
117	6-	4-	2+	6-	4-	6-	1-	1-	2+	1+	1-	2+
116	4-	4-	6-	2+	1+	6+	1+	1-	1-	2+	1+	1+
115	6-	1+	2+	6-	1+	2+	2+	1+	1-	2+	2+	1+
114	6-	6-	2+	6-	6-	6-	1+	1-	1+	1+	1+	1+
080	6-	2+	1+	6-	4-	1+	1-	1+	1-	0	1+	1-
079	6-	2+	4-	6+	2+	1+	2+	1-	1-	2+	1+	1-
071	4+	6-	4-	4+	4-	6+	1+	1-	1-	1+	1+	1+
070	6-	2-	4-	4+	6-	2+	1-	1+	1+	0	2+	2+
069	6-	4-	6-	6-	6-	6-	2+	1-	2-	0	1+	3+
064	4+	6-	6-	4-	0	6-	2-	1-	2-	1-	1-	1+
058	2+	2+	4+	2+	2+	2+	1-	1+	2-	0	1+	1+
065	4-	2-	1+	1-	2-	2-	1-	1+	1+	1+	1+	1+

4. RESPONSES OF OLDER FEMALES (N = 30)

SERIAL NUMBER	FREE CLASSIFICATION						MATRIX					
	2-D STIMULI			3-D STIMULI			2-D STIMULI			3-D STIMULI		
	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 1	TRIAL 2	TRI 3
036	6−	6−	5−	2−	0	2+	3+	1+	1+	1+	1+	1
035	6−	7−	7+	6+	7+	6−	1+	1+	1+	1+	1+	1
034	6+	6−	6−	6−	6−	6−	0	0	0	1+	2−	1
031	6−	4+	0	4+	6−	4+	1+	1+	3+	1+	1+	2
032	2+	1+	0	2+	1+	6−	0	2+	0	0	1+	1
030	6+	6−	1−	2−	3+	6+	2+	2+	2+	3+	1+	1
028	6−	2+	1+	2+	1+	3+	0	1+	3+	1+	1+	1
026	6−	0	4+	4+	1+	1+	1+	2+	1+	1+	1+	1
024	2+	2+	1+	2+	2+	6−	2+	2+	0+	3+	1+	1
019	6−	6−	0	1+	2+	4+	0	3+	2−	1+	1+	1
068	4+	2+	1+	6−	6−	1+	1+	1−	3−	3−	2+	0
075	2+	6−	1+	6−	4−	6−	2−	1+	2−	3+	2+	2+
074	1+	2+	6−	6+	2+	1+	3+	1+	1−	2+	1−	1+
083	6−	2+	4−	2+	4+	2+	0	2+	1−	3+	1+	1+
077	6−	6−	4+	3−	2−	2+	1+	1−	1−	1+	1+	1+
056	6−	3−	1−	2+	3+	1+	3+	1+	1+	1+	1+	1+
055	2+	4+	6+	2+	6+	4+	3+	1+	1+	2+	1+	2+
054	6+	2+	0	2+	6+	4+	2+	1+	1+	2+	1+	1+
053	2+	6+	4−	2+	2+	6+	1+	1+	1+	0	1+	1+
052	2+	2+	4+	2+	2+	2+	2+	1+	1+	1+	1+	1+
072	6−	3−	6+	6−	6+	1−	0	0	0	1+	1+	3+
060	2+	4+	2+	2+	4+	6+	3+	1−	1−	1+	1+	1+
059	2−	2−	6+	3−	2−	2−	1+	1+	1−	1+	1+	1+
076	2+	1+	2+	2+	2+	1+	3+	1+	1+	2+	1−	1−
073	4+	6−	6−	4+	4+	6+	0	1+	1+	0	3+	1+
061	4+	6−	3−	4+	2+	6+	1+	1+	1+	1+	1+	1+
062	2+	1+	2+	4+	1+	2+	2+	1+	2+	1+	1+	2+
063	4−	4−	2−	2−	4+	1+	1+	1+	1+	2+	1+	1+
066	6−	6−	1−	2+	6−	1+	2+	1+	2+	2+	1+	1+
067	2−	6−	3−	2+	6−	1+	0	1−	1−	1−	1−	1−

APPENDIX D

ILLUSTRATION OF STATISTICAL COMPUTATIONS USING SELECTED DATA FROM THE STUDY

1. CHI-SQUARE (df = 1)

AN AGE X TYPE OF RESPONSE CONTINGENCY TABLE OF THE FREQUENCY OF UNI-DIMENSIONAL AND MULTI-DIMENSIONAL RESPONSES GIVEN BY SUBJECTS ON TRIAL 1 USING 2-D STIMULI

AGE	TYPE OF RESPONSE		TOTAL
	UNI-DIMENSIONAL	MULTI-DIMENSIONAL	
9 year olds	37 (a)	19 (b)	56 (k)
12 year olds	22 (c)	38 (d)	60 (l)
TOTAL	59 (m)	57 (n)	116 (N)

Formula Used

$$X^2 = \frac{N(|ad - bc| - ,5)^2}{k\ l\ m\ n}$$

Formula 14,7, *Downie and Heath*, 1974, p. 198.

Computation

$$X^2 = \frac{116\ ((37 \times 38) - (19 \times 22) - ,5)^2}{56 \times 60 \times 59 \times 57}$$

$$= \frac{116\ (1406 - 418 - ,5)^2}{11299680}$$

$$= \frac{116 \times 987,5^2}{11299680}$$

$$= \frac{116 \times 975156,25}{11299680}$$

$$= \underline{10,011}$$

2. CHI-SQUARE (df > 1)

NUMBER OF YOUNGER AND OLDER SUBJECTS SUCCESSFULLY RECLASSIFYING 3-D STIMULI ACROSS TRIALS 1, 2, AND 3.

SUBJECTS	TRIALS			TOTAL
	TRIAL 1	TRIAL 2	TRIAL 3	
Younger	57 (a)	53 (b)	48 (c)	158
Older	60 (d)	58 (e)	59 (f)	177
TOTAL	117	111	107	335

Formula Used

$$X^2 = \Sigma\frac{(O - E)^2}{E}$$

Formula 14,1, *Downie and Heath*, 1974, p. 190.

Computation

Expected Frequency (E) for cell

$$(a) = \frac{158 \times 117}{335} = 55,182$$

$$(b) = \frac{158 \times 111}{335} = 52,352$$

$$(c) = \frac{158 \times 107}{335} = 50,466$$

$$(d) = \frac{177 \times 117}{335} = 61,818$$

$$(e) = \frac{177 \times 111}{335} = 58,648$$

$$(f) = \frac{177 \times 107}{335} = 56,534$$

CELL	O	E	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
a	57	55,182	1,818	3,305	0,060
b	53	52,352	0,648	0,420	0,008
c	48	50,466	-2,466	6,081	0,121
d	60	61,818	-1,818	3,305	0,053
e	58	58,648	0,648	0,420	0,008
f	59	56,534	2,466	6,081	0,108
				X^2 =	0,358

3. McNEMAR TEST FOR CORRELATED PROPORTIONS RESPONSES OF SUBJECTS ON THE FIRST FREE CLASSIFICATION TRIAL AND FIRST MATRIX TRIAL, USING 2-D STIMULI

	FREE CLASSIFICATION	
	UNI-DIMENSIONAL	MULTI-DIMENSIONAL
INCORRECT	21 (a)	7 (b)
CORRECT	20 (c)	12 (d)

Formula Used

$$X^2 = \frac{(|b - c| - 1)^2}{b + c}$$

Formula 17.10.3, *Hays*, 1963, p. 604

Computation

$$X^2 = \frac{(20 - 7 - 1)^2}{20 + 7}$$

$$= \frac{12^2}{27}$$

$$= \frac{144}{27}$$

$$= \underline{5{,}333}$$

4. THREE-FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES AN AGE X SEX X TYPE OF STIMULUS ANALYSIS FREE CLASSIFICATION RESPONSES OF SUBJECTS (N = 30, N = 120) WITH REPEATED MEASURES ON TYPE OF STIMULUS (WINER, 1962)

AGE X SEX X TYPE OF STIMULUS SUMMARY TABLE

SEX	AGE	2-D STIMULI	3-D STIMULI	TOTAL
Male	Older	111	106	217
	Younger	74	75	149
Female	Older	108	104	212
	Younger	65	69	134
	TOTAL	358	354	712

AGE X SEX SUMMARY TABLE

	AGE		
SEX	OLDER	YOUNGER	TOTAL
Male	217	149	366
Female	212	134	346
TOTAL	429	283	712

AGE X TYPE OF STIMULI SUMMARY TABLE

AGE	TYPE OF STIMULI		
	2-D	3-D	TOTAL
Older	219	210	429
Younger	139	144	283
TOTAL	358	354	712

SEX X TYPE OF STIMULI SUMMARY TABLE

SEX	TYPE OF STIMULI		
	2-D	3-D	TOTAL
Male	185	181	366
Female	173	173	346
TOTAL	358	354	712

Computations

1. $G^2/\ n\ ABC$ = $\frac{712^2}{240}$

= 2112,267

2. ΣX^2 = 436 + 418 + 246 + 229 + 167 + 207 + 465 + 414

= 2582,000

3. $\Sigma A^2/nBC$ = $(366^2 + 346^2)\ /\ 120$

= 2113,933

4. $\Sigma B^2/nAC$ = $(429^2 + 283^2)/120$

= 2201,083

5. $\Sigma C^2/nAB$ = $(358^2 + 354^2)/120$

= 2112,333

6. $(\Sigma(AB)^2)/N$ = $(217^2 + 149^2 + 212^2 + 134^2)/60$

= 2203,167

7. $(\Sigma(AC)^2)/N$ = $(185^2 + 181^2 + 173^2 + 173^2)/60$

= 2114, 067

8. $(\Sigma(BC)^2)/N$ = $(219^2 + 210^2 + 139^2 + 144^2)/60$

= 2201,967

9. $(\Sigma(ABC)^2)/N$ = $(111^2 + 106^2 + 74^2 + 75^2 + 65^2 + 69^2 + 108^2 + 104^2)/30$

= 2204,133

10. $\Sigma P^2/r$ = 4946/2

= 2473,000

SUMMARY OF THE AGE X SEX X TYPE OF STIMULI ANALYSIS OF VARIANCE OF THE FREE CLASSIFICATION RESPONSES OF SUBJECTS

SOURCE OF VARIATION	COMPUTATIONAL FORMULA	ss	df	ms	F	p
Between Subjects	10-1	360,733	119			
Sex	3-1	1,667	1	1,667		
Age	4-1	88,816	1	88,816	38,184	0,001
Sex X Age	6-3-4+1	,418	1	,418		
Subject Within Group Error	10-6	269,833	116	2,323		
Within Subjects	2-10	109,000	120			
Type of Stimuli	5-1	,067	1	,067		
Sex X Type of Stimuli	7-3-5+1	,068	1	,068		
Age X Type of Stimuli	8-4-5+1	,818	1	,818		
Sex X Age X Type of Stimuli	9-6-7-8+3+4+5-1	,014	1	,014		
Stimuli X Subject Within Group Error	2-9-10+6	108,034	116			

5. FOUR-FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES
AN AGE X SEX X STIMULI X TASK ANALYSIS OF VARIANCE OF BEHAVIOURAL RESPONSES OF SUBJECTS, WITH REPEATED MEASURES ON THE STIMULI AND TASK FACTORS (Winer, 1962)

A	=	Age	A_1	=	Young	A_2	=	Old
B	=	Sex	B_1	=	Male	B_2	=	Female
C	=	Stimuli	C_1	=	2-D	C_2	=	3-D
D	=	Task	D_1	=	Free Classification	D_2	=	Matrix

n = 30   p = 2   q = 2   e = 2   s = 2

A X B X C X D SUMMARY TABLE

		C_1		C_2		TOTAL
		D_1	D_2	D_1	D_2	
		ΣX (ΣX^2)	ΣX (ΣX^2)	ΣX (ΣX^2)	ΣX (ΣX^2)	
A_1	B_1	74 (246)	134 (874)	75 (229)	166 (1196)	449
	B_2	65 (167)	121 (863)	69 (207)	124 (792)	379
A_2	B	111 (465)	205 (1563)	106 (414)	212 (1598)	634
	B_2	108 (436)	191 (1399)	104 (418)	231 (1845)	634
TOTAL		358	651	354	733	2096

A X B X C SUMMARY TABLE

	C_1	C_2	TOTAL
A_1 B_1	208	241	449
B_2	186	193	379
A_2 B_1	316	318	634
B_2	299	335	634
TOTAL	1 009	1 087	2 096

FOUR FACTOR ANOVA (CONTINUED)

A X B X D SUMMARY TABLE

	D_1	D_2	TOTAL
A_1 B_1	149	300	449
B_2	134	245	379
A_2 B_1	217	417	634
B_2	212	422	634
TOTAL	712	1 384	2 096

A X B X D SUMMARY TABLE

		D_1	D_2	TOTAL
A_1	B_1	149	300	449
	B_2	134	245	379
A_2	B_1	217	417	634
	B_2	212	422	634
TOTAL		712	1 384	2 096

A X C X D SUMMARY TABLE

		D_1	D_2	TOTAL
A_1	B_1	139	255	394
	B_2	144	290	434
A_2	B_1	219	396	615
	B_2	210	443	653
TOTAL		712	1 384	2 096

B X C X D SUMMARY TABLE

		D_1	D_2	TOTAL
B_1	C_1	185	339	524
	C_2	181	378	559
B_2	C_1	173	312	485
	C_2	173	355	528
TOTAL		712	1 384	2 096

FOUR FACTOR ANOVA (CONTINUED)

A X B SUMMARY TABLE

	B_1	B_2	TOTAL
A_1	449	397	828
A_2	634	634	1 268
TOTAL	1 083	1 013	2 096

A X C SUMMARY TABLE

	C_1	C_2	TOTAL
A_1	394	434	828
A_2	615	653	1 268
TOTAL	1 009	1 037	2 096

B X C SUMMARY TABLE

	C_1	C_2	TOTAL
B_1	524	559	1 083
B_2	485	528	1 013
TOTAL	1 009	1 087	2 096

A X D SUMMARY TABLE

	D_1	D_2	TOTAL
A_1	283	545	828
A_2	429	839	1 268
TOTAL	712	1 384	2 096

B X D SUMMARY TABLE

	D_1	D_2	TOTAL
B_1	366	717	1 083
B_2	346	667	1 013
TOTAL	712	1 384	2 096

C X D SUMMARY TABLE

	D_1	D_2	TOTAL
C_1	358	651	1 009
C_2	354	733	1 087
TOTAL	712	1 384	2 096

FOUR FACTOR ANOVA (CONTINUED)

1. $G^2/npqrs$ = $2096^2/480$
   = 9152,533
2. ΣX^2 = 12712,000
3. ΣA^2 = $(828^2 + 1268^2)/240$
   = 9555,867
4. ΣB^2 = $(1083^2 + 1013^2)/240$
   = 9162,742

5. $\Sigma\ C^2 = (1009^2 + 1087^2)/240$

$= \underline{9165,\ 208}$

6. $\Sigma\ D^2 = (712^2 + 1384^2)/240$

$= \underline{10093,333}$

7. $\Sigma\ AB^2 = (449^2 + 379^2 + 634^2 + 634^2)/120$

$= \underline{9576,\ 283}$

8. $\Sigma\ AC^2 = (394^2 + 434^2 + 615^2 + 653^2)/120$

$= \underline{9568,550}$

9. $\Sigma\ BC^2 = (524^2 + 559^2 + 485^2 + 528^2)/120$

$= \underline{9175,550}$

10. $\Sigma\ AD^2 = (283^2 + 545^2 + 429^2 + 839^2)/120$

$= \underline{10542,\ 300}$

11. $\Sigma\ BD^2 = (366^2 + 717^2 + 346^2 + 667^2)/120$

$= \underline{10105,\ 416}$

12. $\Sigma\ CD^2 = (358^2 + 651^2 + 354^2 + 733^2)/120$

$= \underline{10121,416}$

13. $\Sigma\ ABC^2 = (208^2 + 186^2 + 241^2 + 193^2 + 316^2 + 318^2 + 299^2 + 335^2)/60$

$= \underline{9596,600}$

14. $\Sigma\ ABD^2 = (149^2 + 134^2 + 217^2 + 212^2 + 300^2 + 245^2\ 417^2 + 422^2)/60$

$= \underline{10569,800}$

15. $\Sigma\ ACD^2 = (139^2 + 144^2 + 219^2 + 210^2 + 255^2 + 290^2\ 396^2 + 443^2)/60$

$= \underline{10571,800}$

16. $\Sigma\ BCD^2 = 185^2 + 181^2 + 173^2 + 173^2 + 339^2 + 378^2\ 312^2 + 335^2)/60$

$= \underline{10133,633}$

17. $\Sigma ABCD^2$ $= (74^2 + 65^2 + 111^2 + 108^2 + 134^2 + 121^2$
$205^2 + 191^2 + 75^2 + 69^2 + 106^2 + 104^2$
$166^2 + 124^2 + 212^2 + 231^2)/30$

$= \frac{318\ 464}{30}$

$= \underline{10615,467}$

18. $\Sigma CP^2/r$ $= (1^2 + 10^2 + 1^2 \ldots\ldots 10^2 + 12^2 + 13^2)/2$

$= \underline{10710,500}$

19. $\Sigma DP^2/r$ $= (2^2 + 8^2 + 2^2 \ldots\ldots 17^2 + 15^2 + 17^2)/2$

$= \underline{11997,500}$

20. $\Sigma P^2/pq$ $= \frac{42289}{4}$

$= \underline{10572,250}$

I $= \underline{9152,533}$

Between Subjects $= 10\ 572,250 - 9152,533$

$= \underline{1419,717}$

Σx^2 for A $= 9555,867 - 9152,533$

$= \underline{403,337}$

Σx^2 for B $= 9162,742 \quad 9152,533$

$= \underline{10,209}$

Σx^2 for AB $= 9576,284 - 9555,867 - 9162,742 + 9152,533$

$= \underline{10,208}$

SA'B' $= 10572,250 - 9576,284$

$= \underline{995,966}$

Σx^2 for C = 9165,208 - 9152,533

= 12,679

Σx^2 for AC = 9568,550 - 9555,867 - 9165,208 + 9152,533

= 0,008

Σx^2 for BC = 9175,550 - 9162,742 - 9165,208 + 9152,533

= 0,133

Σx^2 for ABC = 9596,600 - 9576,283 - 9568,550 - 9175,550 + 9165,208 + 9555,867 + 9162,742 - 9152,533

= 7,501

SC A'B' = 10710,500 - 9596,600 - 10572,250 + 9576,283

= 117,933

Σx^2 for D = 10093,333 - 9152,533

= 940,800

Σx^2 for AD = 10542,300 - 9555,867 - 10093,333 + 9152,533

= 45,633

Σx^2 for BD = 10105,416 - 9162,742 - 10093,333 + 9152,533

= 1,874

Σx^2 for ABD = 10569,800 - 9576,283 - 10542,300 - 10105,416 + 9555,867 + 9162,742 + 10093,333 - 9152,533

= 5,210

SD A'B' = 11997,500 - 10572,250 - 10569,800 + 9576,283

= 431,733

Σx^2 for CD = 10121,416 - 9165,208 - 10093,333 + 9152,533

= 15,408

Σx^2 for ACD = 10571,800 - 9568,550 - 10121,416 - 10542,300 + 9555,867 + 9165,208 + 10093,333 - 9152,533

= 1,409

Σx^2 for BCD = 10133,633 - 9175,550 - 10105,416 - 10121,416 + 9162,742 + 9165,208 + 10093,333 - 9152,533

= 0,001

Σx^2 for ABCD = 10615,467 - 9596,600 - 10569,800 - 10571,800 - 10133,633 + 9576,283 + 9568,550 + 10542,300 + 9175,550 + 10105,416 + 10121,416 - 9555,867 - 9162,742 - 9165,208 - 10093,333 + 9152,533

= 8,531

SCD A'B' = 550,900

AGE X SEX X STIMULI X TASK ANALYSIS OF VARIANCE SUMMARY TABLE OF RESPONSES OF 120 SUBJECTS ON CLASSIFICATION TASKS

SOURCE OF VARIATION	SS	df	MS	F	p
A (AGE)	403,332	1	403,337	46,976	<0,001
B (SEX)	10,209	1	10,209	1,189	
A X B	10,208	1	10,208	1,189	
S A'B'	995,966	116	8,586		
C (STIMULI)	12,679	1	12,679	12,467	<0,001
A X C	,008	1	,008		
B X C	,133	1	,133		
A X B X C	7,501	1	7,501	7,376	<0,001
S C A'B'	117,933	116	1,017		
D (TASK)	940,800	1	940,800	252,767	<0,001
A X D	45,633	1	45,633	12,260	<0,001
B X D	1,874	1	1,874	,503	
A X B X D	5,210	1	5,210	1,400	
S D A'B'	431,733	116	3,722		
C X D	15,408	1	15,408	3,244	<0,05
A X C X D	1,409	1	1,409	,376	
B X C X D	,001	1	,001		
A X B X C X D	8,531	1	8,531	1,796	
SCD A'B'	550,900	116	4,749		

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