A STUDY OF SOME ASPECTS OF CLASSIFICATION AND GROUPING

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ABSTRACT

This investigation is concerned with how children group objects and with the underlying rules they may use to categorize experience. The sample consisted of three hundred and twenty children with equal numbers of boys and girls in each group of eighty, five, eight, ten and twelve year olds. Subjects were given two free sorting tasks using attribute blocks and an array of everyday objects. Verbal explanations were recorded. Developmental trends were sought in terms of the numbers of groups formed (discrimination), criteria chosen as the basis for grouping, and the potency of stimulus material as a possible determinant of criteria. The differences in logical sorting, pattern making and figural arrangements were examined and also found to be age rather than sex related. Language responses showed increasing sophistication in criterial choice and in the ability to explain groupings.

Highly significant results were obtained showing age related trends for all groups. Younger subjects formed more groups which they were less able to explain than older children. Younger children showed more responses with partial logic and simple pairing of objects, and they also formed groups on the basis of perceptible (colour, shape, size), while older children used more functional criteria (use). Older subjects showed greater stability in logical grouping and formed fewer groups, each with more objects. Attribute blocks evoked more geometric pictorial and pattern making in younger children than did array materials. Significance was not found for any of the independent variables except age. These included sex, age, parental occupation, size of family, position in the family, pre-school and school attendance.

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INTRODUCTION - SOME PERSPECTIVES IN CLASSIFICATION

In investigating classification one is first concerned with how people group objects and then with the ways in which they categorize experience (Nixon 1971). Bruner (1966) defines a category as a rule for classifying objects as equivalent. He sees categorization as ordering and simplifying environmental complexity and reducing the necessity for constant learning. This permits us to see relationships and to make comparisons between classes of events, while at the same time it minimizes error, for it enables us to save time and energy in decision making. Sokal (1974) considers classification as the recognition of similarities in patterns of sensory input.

The present investigation is concerned with children's classificatory and grouping behaviour within the area of cognitive psychology. A number of developmental investigations on the formation of class concepts have been conducted over the years. Simple sorting tests have generally been employed with subjects required to match test materials or to freely sort them. Instructions are usually minimal to encourage free and spontaneous sorting. (See footnote.)

Thompson (1941) administered Vygotsky, Weigl Colour-form, and other tests to children aged from six to eleven years. She found that the younger children tended to see no objects that belonged together or to class objects together in concrete situations. The present investigation disagreed with these findings since 90% of the five year old subjects produced grouped material which included groups with at least two objects as belonging together. Thompson also reported that the older subjects formed more categories on an abstract basis. She observed a definite qualitative and quantitative change in the ability to handle abstractions between the age range of six to eight years and nine to eleven years.

Footnote:
A wide range of relevant research literature also emanates from clinical psychology, perceptual studies, behaviour and learning theory. Readers who are concerned with these aspects of classification are referred to the bibliography and to Appendix 2.

Reichard, Sneider & Rapaport (1944) tested 234 children aged between four and fourteen using Weigl's colour-form test. They noted three levels in the development of class concept linked with age. The first "concretistic" stage gave way to a functional stage at between eight and nine years when children demonstrated consistent classification based mainly on use. More mature conceptual classification developed at about eleven years of age. The present study (TABLE VIII) shows that object sorting (arrays) responses have increased from 3% in five year olds to 18% in eight year olds. It agrees also with the tendency to more mature conceptual classification in twelve year olds here demonstrated in their explanation of groups. Similar findings were noted by Sigel (1953). Sixty children aged seven, nine and eleven were required to sort arrays of environmental materials and pictures. Here chronological age, social class and mental ability were controlled. Explanations were required and the tester took account both of perceptual and linguistic response to the tasks. Sigel reported that younger children were more closely tied to the perceptual cues of the stimulus material. Subjects showed an increase in higher or conceptual classification and less dependence on earlier perceptual or mixed groupings with increased age. A notable feature of these tests was the amount of individual variation found within groups. More recently Nelson (1974) studying the natural language categories of five and eight year old children found that age changes appeared to be related to increasing articulation and hierarchical expansion of categories, and that both ages showed reliance on functional definition.

Annett (1959) studied 303 children aged between five and eleven years, and forty-two adults between eighteen and seventy-three years. Tests consisted of sorting sixteen cards depicting common environmental objects, and explanations were recorded. Annett isolated three developmental categories. (a) "Contiguity", in which objects are directly related as "going together". (b) "Similarities", in which objects are classified on the basis of shared similarities, and (c) "class name", which includes such generic terms as "household objects". Annett obtained over 200 different combinations of cards, half of which were unique.

While each type of sorting was present within each group, sortings showed a clear change in so far as the number of combinations reduced as age increased. While Annett's study demonstrated a progression in the development of logical thinking with age, some older adults resembled younger children in giving more enumeration and contiguity responses. This finding is in keeping with that of Denney (1972). Many children and adults used more than one method of explanation. Annett suggests that people may vary in the developmental stage reached, and that individuals may not develop all conceptual stages simultaneously. Evidence for this was also found by Lovell (1961) in classificatory tests where primary school and E.S.N. children were tested, each child receiving the full complement of five tests. Steiner (1975) also argues for less stage-age explanation for these tasks.

Vygotsky (1962) used blocks with letter symbols to study language and concept development. Each subject was given two sets of stimuli and some 300 children, adolescents and adults were tested. Vygotsky describes three basic phases, each divided into several stages of concept development. Firstly, the young child perceptually forms "syncretic heaps" with groupings at random or through contiguity in space. In the next "complexive" phase, the child no longer mistakes connections between his own impressions for connections between things, groups are now formed on the basis of shared similarities of attributes and the bonds between the components are concrete and factual. Objects are grouped on the basis of their participation in the same practical operation, or on their function. Diverse objects such as cups, saucers, plates = dishes. Hats, singlets, jumpers, socks = clothes.

Complexive thinking is made up of chain complexes, fluid complexes and pseudo complexes, all of which lack grouping consistency. In chain complexes "... an object included because of one of its attributes enters the complex not just as a carrier of that one trait but as an individual, with <u>all</u> of its attributes. Thus the single trait is not abstracted by the child from the rest". (P.64) Pseudo concepts develop next which lack the criteria of true logical grouping.

The final phase cited by Vygotsky is that of the true concept which begins to develop during adolescence when the primitive syncretic and complex forms of thinking gradually subside and true abstract thinking emerges. The conventional superordinate category emerges governed by logical (syntactical rules). Words enable us to abstract, synthesize and symbolize concepts. Vygotsky's theoretical construct is based on linguistic meaning.

Denney (1972a) attempted to replicate Vygotsky's tests but she was unable to observe developmental stages similar to those described by Vygotsky. Vygotsky's work is of particular interest because of his descriptions of syncretic heaps and chaining complexes which resemble grouping behaviour observed in this investigation. Why we may ask, did Denney achieve such inconclusive results in her replication study? The present investigation clearly showed examples of complexive sorting despite the use of different stimulus blocks.

Like Vygotsky, Bruner regards cognitive development as emphases rather than stages.

Bruner & Olver (1963), investigated equivalence formation in their research into concept formation and grouping strategies. The stimuli used in these experiments were card illustrations of a variety of familiar objects including such things as fruit and musical instruments. Bruner also described developmental sequences in his subjects, and established rules for grouping. "Firstly, the subject selects only a fraction of the properties available for grouping, and this achieves a reduction in load. Thus we may group oranges, apples, pears and bananas as fruit, while ignoring such attributes as colour, shape, or keeping quality. Such groupings always involve less than the sum of the discernible elements. The second grouping rule has the property of being generalizable, so that if more of the group were known, knowledge of the grouping rule would still permit one to regenerate the elements by relating them to prior known groupings. But simplicity and reproducibility are not the only goals of the grouping process. Others include providing a basis for categorizing future objects and events relating previously established concepts, and moving ahead to new levels of conceptual activity".

More recently Muyunder (1974) studied coding of random patterns in six and nine year old children and Bruner & Olver (1963) showed that imaginal systems worked better than verbal ones for spatial and shape organization of patterns.

Work in the development of equivalence formation was followed by an array of experiments designed to investigate cognitive growth. Bruner & Olver (1963) investigated changes in grouping from childhood to adulthood, which are produced by changes in the rules by which data from the world is transformed and organized. In experiments carried out to test the hypothesis of change, children of various ages were given diverse arrays of items presented sequentially but in a form progressively more diverse. The results indicated such equivalence grouping shows a gradual transition "from the association of items into complexive structures on the basis of diverse characteristics to the unification of items into superordinate structures based on a common characteristic ... the young child deals with the single characteristic or impression that is most vivid at the moment, usually a perceptible attribute of the object. Next the child develops a common attribute in terms of himself - how he can act upon the objects. Later the child places himself in a reciprocal relation to the objects (decentralization occurs)".

Olver & Rigney (1966) traced the development of equivalence in sixty subjects aged six, nine, eleven, thirteen, fifteen and eighteen years. They maintain that with enactive representation equivalence is based on a common rule in some action, while equivalence with Ikonic representation is more likely to be accomplished by grouping items according to perceptual kinship or likeness. With the achievement of symbolic representation, equivalence is expected to be governed by grammatical rules. Olver & Rigney reconsidered the issue of syntax equivalence raised by Vygotsky's experiments. They distinguished three general groupings. Groupings are formed on the basis of perceptible attributes (colour, shape, size), functional attributes (i.e. by use), affective attributes (by emotional response), and linguistic convention (from an existing language term).

Different grouping strategies emerged. Superordinate concept formation occurs where items are grouped on the basis of one or more attributes common to them all, i.e. "they all made a noise". Complex formation is characterized by construction on the basis of several different attributes, none of which need be common to all items in the group. Finally, thematic groupings occur, and here construction is on the basis of several different attributes, there is co-occurrence of the items in a story or theme.

Degrees of inclusiveness in groupings were observed. Firstly, grouping was specific to each item. Next, some limited inclusion occurred, which yielded information about some members of the group, and which could be extended to meet new situations. Finally, fully inclusive grouping occurred which applied to all members of the groups.

The use of language was observed where nouns, verbs, adjectives etc. were used in forming groups. The linguistic framework was related directly to Bruner's taxonomy of perceptible, functional and affective bases. They concluded that with younger children, complex formation groups occurred where language was concerned with the perceptible properties of objects. Where superordinate groups were produced, the functional mode operated. Older children showed an increasing tendency for both complexes and superordinate complexes to be formed by the use of language in the functional mode. The shift from concentration on surface perceptible properties to the more embracing functional properties would seem to make possible the development of more efficient and simpler grouping strategies. Why, one may ask, did the present study show so few affective responses and thematic groupings when the rest of the findings agreed with those of Olver & Rigney?

Nelson (1974) studied the composition of natural language categories in five and eight year old children. Age changes occurred primarily as an increase in the number of responses given, and these appeared to be related to the increasing articulation and hierarchical expansion of categories. Both ages showed reliance on functional definitions of category memberships. What proportion of perceptible functional responses are to be found in five, eight, ten and twelve year old children in the present study?

Piaget bases his work on biological and logico-mathematical operations which he considers as models of cognitive structure, and he maintains that true classification involves operational understanding of the logic of classes as revealed in children's handling of hierarchical class structures. Psychologically, an operation can be described as an action which can be internalized and which is reversible.

Piaget made use of certain structures, notably the group, the lattice, and certain algebraic and topological structures. "Thus if Piaget says that classificatory behaviour of an eight year old demonstrates the presence of logical class addition, he means that children can demonstrate the same formal properties possessed by the logico-algebraic model i.e. reversibility, associativity, composition, tautology etc. He infers from the child's behaviour in classifying that the child's cognitive structure has similar properties". Flavell (1969) P. 169.

Inhelder & Piaget (1964) describe the results of a number of tests with 2159 children in which they used sorting and other test methods to study the operations of classification and seriation. Inhelder & Piaget (1964) describe three main stages in the development of classification. (1) Graphic collections as a first attempt to synthesize intension and extension. (2) Non-graphic collections as an additive classificatory structure. (3) Class inclusion and hierarchical classifications.

In describing graphic collections Piaget lists several phases which tend to overlap and which do not always appear in the same sequence. Firstly, alignments, which are usually linear arrangements and may be continuous or discontinuous in their criteria. Do the alignments described by Piaget seem to resemble Vygotsky's "chain complexes"? Some of the arrangements observed in the present investigation seem to indicate that they do. e.g. Figures 19a and 19b. Next "collective objects" are described as two or three dimensional arrangements again with fluctuating criteria, and finally "complex objects", grouping based on genetical or situational content. These resemble some of the figural arrangements in the present study. Denney (1972a, 1972b) failed to replicate the work of Inhelder & Piaget in demonstrating alignments and other phases of non-graphic collections. At this stage, although the child may sometimes begin by sorting objects which are alike by putting them together one at a time on the basis of resemblance, he seems to have no recognition of the whole set. (See Figures 14a and 14b). Spatial proximity and other perceptual cues such as colour influence the arrangement at this stage. Grouping is still so unstable that although sorting by similarity of attributes may occur, logic is soon destroyed by the inclusion of a non-class.

Inhelder & Piaget's second phase in the development of classification is that of "non-graphic collections" in which objects are grouped by similarity alone. Four kinds of non-graphic collections are described. (a) A number of different groups are assembled, each on the basis of different criteria but which do not include all the blocks. These were observed in only one case in the present study (Figure 20). (b) Groups are again based on different criteria but here all the stimulus material is included. (c) All blocks are assembled into groups based on the same criterion. (d) Finally all groups are based on the same criterion and then further subdivided according to the same second criterion. Many instances of these kinds of sortings appeared in the present study but they occurred with considerable variation across ages. Although the child at this stage forms groups of objects on a similarity of attributes basis and tries to form groups within groups, the principle of class inclusion is not yet fully established. Children's groupings fail to fulfil the criterion of classes at this stage because they lack the properties of comprehension and extension.

The child's ability to coordinate comprehension and extension, and hence to classify, depends upon the control of logical quantifiers "the", "some" and "all". i.e. All A are B, but only some B are A. $A^{+} + A' = B$ provided A' is not an empty class.

Although the child may indeed recognize that the subclass A is included in class B, he cannot recognize that $A = B - A'$ and keep this A-B relation firmly in mind across all manner of changes including spatial distribution of class and subclass.

The act of categorization results in the grouping of objects according to one or more of the attributes which they have in common. Such grouping underlies the formation of classes. The development of the concept of class occupies a central position in Piaget's accounts of the development of logical thinking in middle childhood, since mathematical reasoning also consists of reasoning about classes and class membership.

Inhelder writes, "The affective operation of the child's concrete thinking and of the formal thinking of the adolescent constitute among themselves closed systems of which the most important characteristic is their reversibility ... Piaget distinguishes two forms of reversibility: inversion (negation) and reciprocity. At the level of concrete logical thought, negation applies to the classificatory operations, and reciprocity to those involving relations. While the thinking child of less than six years (in Switzerland at least) is still characterized by the absence of reversibility, from six to eleven years the child can already achieve in given situations, one or other, but not both, of these forms of reversibility". Furth (1969) P. 261.

A recent paper by Keating (1975) asks if the development of formal operations in fifth and seventh grade children is related to measured intelligence? He suggests a relationship between precocity in attaining formal operational thinking and high intelligence scores.

".... Those more able adolescents who come to handle formal and propositional operations use the two forms of reversibility simultaneously. These two sets of operations form an unitary system which corresponds to the model of the four transformations (I.R.N.C.) described by Piaget.

I = Identity	N = Negation	NR = C;CR = N
R = Reciprocity	C = Correlation	CN = R;NRC = I

This double reversibility confers a high degree of mobility and coherence upon formal thought". (ibid) Taylor (1971) criticizes the I.N.R.C. group lattice structure.

At the formal operations stage somewhere from eleven years onwards, the child is able to cope with hierarchical classification. With the development of the capacity to manipulate hierarchical ordering, the young person can now see a problem as a whole and see a multiplicity of viewpoints. His thinking is now "mobile", symbolic, and largely freed from perception. He can grasp and use several criteria for classification which enables him to formulate and systemmatically test hypotheses, and he is capable of understanding the calculus of propositions and of performing second order operations in logic.

Lovell et al (1961) repeated seven of Piaget's classification and three number experiments. These investigations were carried out in two parts and involved groups of fifty primary school children and varying numbers of E.S.N. pupils aged between nine and fifteen years. All subjects received each of the tests. Children in stage I showed no consistency in their actions and were unable to see and plan the next step (a finding in keeping with the present study). At stage II the beginning of a construction seemed to be remembered. Lovell's results confirmed the view of Piaget & Inhelder in the ability to achieve stage III (operational ability is achieved by primary school children at about the same time in addition of classes, multiplication of classes, visual seriation and multiple asymmetrical transitive relationships). Macnamara (1975) argues however, that Piaget's account of how children develop an understanding of number is erroneous. He contends that number bears only an accidental relationship to a system for classifying objects and states also that seriation cannot serve as the basis for discriminating objects. Brainerd (1973) also challenged Piaget's findings since his own research indicated that transitivity was found to emerge before class inclusion.

From his second series of experiments, Lovell found that E.S.N. pupils differed in perceptual mode from other primary school children. This seemed to suggest that simple classificatory tasks do not greatly depend on language. The equivalence findings of Bruner et al (1966) in his studies of Mexican and Eskimo children with and without schooling, also suggest that the language and environmental training may have their affect on the perceptual and cognitive mode adopted by different groups.

Dodwell (1968), investigated classification behaviour using the model and applying scalar techniques, his findings were however inconclusive.

Other studies which have reinvestigated aspects of Piaget's classification work are those of Wohlwill (1968), Sigel (1971), Wohlwill & Lowe (1972), Brainerd (1974), Denney (1972b and Nixon (1971) (1973). Recently also Ahr & Youniss (1970) & Kahl et al (1974), Sheppard (1973) and Talensky (1974), investigated some facets of training and test procedures in classification and Drummond et al (1973) the issue of age and class inclusion. These various investigations have helped to demarcate the parameters of the theory, but despite the criticisms of methodology and stage theory, Piagetian descriptions of the sequence in stages of cognitive growth have withstood the barrage of research.

Several studies have appeared which seek to establish connections between grouping behaviour and cognitive style. Initial work in the area consisted of block-sorting Gardner (1953),card-matching Bruner & Tajfel (1961) Kagan (1963), and category width paper and pencil tests Pettigrew (1958). More recent work has centred around classification and cognitive - impulsivity Bjorklunk & Butler (1973), reflection-impulsivity and logical classification, Panckhurst (1971), and problem solving strategies in reflective-impulsive children Ault (1973), Sigel & Kilberg (1973), Weiner & Berzonsky (1975).

Gardner & Schoen (1962) established a possible link between the function of few groups on an object sorting test (broad categorization) and creativity. Connections were sought between breadth of categorization and conceptual style. Kagan et al (1960) designated styles as being descriptive, categorical-inferential, and relational <u>or</u> as analytical and relational. A child with analytic cognitive style was found to group stimuli according to their similarities, whereas one demonstrating a non-analytic approach might grasp the same set of figures by affective criteria, "Those I like". With age, analytic responses tend to increase and relational to decrease. Analytic thinkers differentiate the stimulus environment and are better able to separate relevant from irrelevant fields. Non-analytic children are found to be more "field-dependent", more impulsive and more susceptible to immediate perceptual experiences. Witken et al (1962).

Wallach & Kogan (1965) asked what correlationships might exist between the various categorizing and conceptualizing tasks. They found that correlations were generally low. They also found that conceptual style indices derived from object sorting revealed a significant sex difference in descriptive response. Witkin et al (1962) also demonstrated the consistent tendency of boys to analytic functioning in conceptualizing and not girls. Wallach & Kogan (1965) obtained a relationship between category breadth and creativity for girls but not for boys. Wallach & Kogan treat categorization as a problem in preference for narrow versus broad categories, and conceptualization as a matter of structural characteristics of the concepts employed when grouping or integrating diverse arrays of stimuli.

More recently, Panckhurst (1971) used matching-figure classification tests to study reflection-impulsivity in girls, which relates to Kagan's relational, analytic-descriptive, and inferential-categorical cognitive style dimensions. Panckhurst points to developmental sequences which show increasing ability to make abstraction in classification tasks. She compares the classification work of Annett (1959), Inhelder & Piaget (1964) and Kagan, Moss & Sigel (1963, 1964).

Are there, one may ask, connections between the number of groups formed in an object-sorting test and the age and sex of subjects? Does the observed behaviour of some subjects who form few groups reflect equivalence range and is it also sex-related?

Conclusions

The larger studies of classification reviewed above have made extensive use of simple sorting tests. Such tests have been criticised on the grounds of artificiality, a charge which may be levelled at almost all test situations and which is inherent in their very nature. A more valid criticism is that such tests produce a great variety of responses, the wealth of which inevitably leads to subjectivity in interpretation and makes sound generalizations exceedingly difficult. Probably more serious in this area is the lack of standardization of either tests or procedures.

A variety of theoretical orientations have emerged with the researches outlined above. Some investigators have relied purely on observation for their results, Thompson (1941), Annett (1959); Some have created models, Piaget (1964), Bruner (1966), Vygotsky (1962) and the cognitive style theorists, while others again have followed existing models - Denney (1972), Lovell (1962), Sigel (1953) and Panckhurst (1971).

Particular theoretical views have also affected the issues of language and culture with regard to classification studies. It has been suggested that class concepts are less dependent on verbalization for their formation, Piaget (1964), Lovell (1962), Brainerd (1974); are largely shaped by language, Vygotsky (1962); or are strongly influenced by language, Bruner et al (1966). Price-Williams (1966), Bruner et al (1966) and DeLacey (1970, 1971), have variously compared groups of children living as food-gatherers or in a rural environment, and their peers in school. Interpretations concerning the influence of language and the cultural milieu seem to suggest that the culture may modify classification performance by developing perceptual or intellectual skills in different ways for different groups.

Elementary classification, the discrimination of classes of objects on the basis of common features has been observed in quite young children, Stott (1961), Greenberg & Blue (1975).

Lovell et al (1962) showed that E.S.N. pupils tended to use tactile-kinesthetic perception to classify, while normal pupils relied more upon visual perception. More recently, Farnham - Diggory & Gregg (1975) showed that while form properties were more difficult for children than adults, these were more readily extracted and classified if children used familiar objects. Hale & Piper (1973) found that colour facilitates learning of stimulus material in classification, while Aiken & Williams (1975) described how a multiplicity of attributes were used to classify polygons. Issues relating to where discrimination ends and concept formation begins is a controversial subject, Kendler T. (1961), Ash (1975).

The most consistent finding from classification studies concerns the function of age in intellectual development. The issues of stages is less clear. Are sequential, overlapping or discrete stages present or are they partly a matter of interpretation? The concept of stages in the literature of classification provides a multiplicity of answers.

The research so far discussed raises a number of questions of interest tothe present investigation. Most of the findings show a development from concrete or use criteria as the basis for groupings, through to more abstract criteria used in early adolescence. The present study is not designed to show the demarcation of stages in children's classificatory behaviour, but it is concerned to show changes with age in the cross-sectional samples of five, eight, ten and twelve year old children. This study uses different test materials and it is not intended to replicate the work of Vygotsky, Bruner or Piaget. However, the groups which emerge are scrutinized for resemblances to those described by the cognitive development theorists. Grouping criteria are examined in terms of their perceptual and language properties and these are considered in relation to Bruner's thesis on equivalence sorting.

While Gardner (1953) observed equivalence range in his object sorting task as being related to the number of groups formed, the present investigation seeks to determine the generality of this phenomenon, its frequency with age, and whether it occurs more in boys than in girls, as the literature suggests. Thus the present study was devised to investigate classification within the broad areas of discrimination, preferred discriminatory mode, and criterial choice. Age, sex and some aspects of family background and schooling are also considered. Hypotheses to investigate, sample description and testing procedure, are presented in the next chapter.

GROUPING AND CLASSIFICATORY BEHAVIOUR

Research questions and developmental trends

This investigation is concerned with how children group objects and with the underlying rules they may use to categorize experience. Inhelder and Piaget (1964), have observed that children (2-4) seldom make groups (except perhaps accidentally). From explorations of objects around them they begin to respond to differences and similarities in size, shape, texture, colour, etc. They come to handle different things in different ways and for different purposes, as grouping concepts begin to emerge. Slightly older children group objects by placing them in lines or heaps, with each object linked to the previous one by some sort of similarity. From one pair of objects to the next, the basis of similarity is likely to change. Thus objects one and two may be similar in colour, the next two the same shape, and so on. Although such a collection of objects may look random, the child who builds it up may be using rules of class grouping, even if he is not using such rules consistently.

As has been shown by Inhelder and Piaget (1964), Bruner et al (1966) and Vygotsky (1962), grouping behaviour shows a progression in growing complexity in the number of variables involved and in the kinds of groups formed, which seem to relate to maturing thinking abilities. One may ask how accurately and consistently children use rules about grouping, and inquire how this ability to use rules changes with age, and whether boys and girls differ in this. Children may give clues as to the behaviour involved if they are asked to explain verbally the reasons for the groupings they have made.

Wallach and Kogan (1965), observed that in sorting objects, people may produce few or many groups. How consistent is this tendency, and does the nature of the material produce variations in the phenomenon? If subjects are tested and the conditions varied, then comparisons can be made between the two situations.

The question directing this study was concerned with the extent to which developmental trends in grouping and classificatory behaviour might be evident in cross-sectional samples of five, eight, ten and twelve year old school children. Grouping and classificatory behaviour were examined in terms of age differences and the numbers of groups formed, the inclusiveness of groups, the criteria used as the basis for grouping, differences in stimulus material (attribute blocks or arrays of everyday objects), and the sorting behaviour of children.

Purpose of the investigation

The brief review of some of the literature in classification provides the basis for further research into some aspects of classification, the areas of particular interest being related to the work of Piaget and Bruner in the developmental psychology of cognition.

The purpose of the present study is to investigate some aspects of classification which may demonstrate developmental trends in children's thinking. Firstly, the simplest classification behaviour consists of grouping objects, and hypotheses are here concerned with the kinds and numbers of groups formed. The present investigation seeks to find out how consistent grouping behaviour is in terms of age and sex, while observing the complexity of groups and relating these to maturing thinking abilities.

In grouping objects, children show a progression from grouping by a single attribute, to the use of several attributes. The present study investigates the ability of children to sustain logical grouping, and how this may vary with age. This study is also concerned with the criteria used as the basis for grouping and with the differences in choice of criteria such as shape, size, colour, and so on, which may vary with the age of the subject.

In using both structured material (Invicta attribute blocks), and unstructured material (an array of common household objects), the study seeks to compare grouping behaviour in terms of the different stimulus materials.

Finally, questions arise relating to pattern making, which appears to be linked with grouping behaviour in younger children. This study sets out to investigate the type of sorting observed, that is, forming complex groups, or pairing and singles grouping of objects. The investigation is also concerned with the spatial arrangement of related objects and these are examined in terms of geometric, figural and fantasy arrangements and linked to age and sex of the subjects. Thus the numbers of groups formed, the basis of grouping, and the matching behaviour of subjects are looked at in relation to hypotheses formulated.

Hypotheses to investigate

The first research question to be investigated concerned the numbers of groups formed by children of different ages. Pretest observations of student sorting behaviour showed that while adults tend to form inclusive groups, usually with three or more objects fitting such chosen criteria as shape, size, texture and so on, five year old children tended to form many groups, sometimes with objects placed singly or side by side.

The research hypothesis was formulated to state that five year old children would tend to form more groups as pairs or singles arrangements with both array materials and attribute blocks, while eight, ten and twelve year old children would tend to form fewer groups with more objects within each group.

The second question concerned the observed tendency of some subjects to form few groups each with many objects ("inclusive discriminators"), and of other subjects to form many groups with few objects in each ("specific discriminators"). For the purposes of this investigation an individual is considered to form few groups if he produces two or three groups, and to form many if he produces more than three groups. The null form of the relevant hypotheses are set below.

It was hypothesized that there would be no significant difference between the proportions of five, eight, ten and twelve year old children who were inclusive discriminators.

It was also hypothesized that there would be no significant difference between the proportion of boys who were inclusive discriminators and the proportion of girls who were inclusive discriminators.

It was further hypothesized that the tendency of individuals to demonstrate inclusive discrimination would not differ significantly from array stimulus material to attribute stimulus material.

The third cluster of hypotheses was concerned with the criteria used as the basis of grouping. Pretest data showed that a few subjects name all their groups by a single criterion such as colour, thus indicating a strong preference for the chosen criterion. Those cases where subjects used a single criterion such as colour, size, shape, etc. were examined for developmental trends which might be interpreted in terms of age. The research hypotheses examined were:

That eight, ten and twelve year olds would typically use two or more criteria as the basis for their groupings with both blocks and arrays whereas five year olds would use one or two criteria as the basis for their groupings.

That five year olds would group objects more frequently than eight, ten and twelve year olds on the basis of responses which could be classified as affective or perceptible. (See footnote.)

That five year old children would typically tend to form groups which lack logical criteria as their basis.

The fourth question investigated was concerned with the potency of the stimulus material as a determinant of grouping behaviour. It was anticipated that subjects would group structured material such as Invicta attribute blocks by criteria different from those used to group an array of unstructured material. Two research hypotheses follow:

Thus it was hypothesized that five, eight, ten and twelve year old children would group structured attribute blocks by different criteria from those

Footnote:

Bruner, J.S. and Olver, R.R. (1956), describe perceptible modes for equivalence groupings as..."the child may render items as equivalent on the basis of immediate phenomenal qualities such as colour, size, shape on the basis of position in time and space...and the child may base equivalence on the use of function of items, considering either what they do or what can be done to them" ...p.71-72.

used to group an array of unstructured material.

It was further hypothesized that individual children would group structured and unstructured material by different criteria.

The final research question examined the sorting behaviour of children in relation to pattern making. Pretests had shown that when asked to group objects, some children produced patterns and figural arrangements. The null hypothesis formulated to test this behaviour are stated below.

It was hypothesized that there would be no significant difference between five, eight, ten and twelve year old children in the number of patterned or figural arrangements produced.

It was hypothesized that there would be no significant difference between boys and girls in the numbers of patterned or figural arrangements produced.

It was further hypothesized that there would be no significant difference between the numbers of patterns and figural arrangements produced, regardless of whether the subjects were using array materials or attribute blocks.

DESCRIPTION OF THE SAMPLE

The present study is concerned with investigating grouping behaviour which may be interpreted in terms of a number of independent variables such as age, sex, number and position in family, pre-school attendance, and parental occupation.

School age children were tested in this study because language and communication problems ruled out the use of younger subjects. A cross-section of five, eight, ten and twelve year old children was required, and two Palmerston North schools, Awapuni and Roslyn were chosen because children in these schools had similar backgrounds in terms of parent occupation (see footnote). The selection of children was done by the Headmaster or the Supervisor of Junior Classes who provided a representative range of pupils chosen in terms of age and ability.

The tests were given to 80 five, eight and ten year old children, 20 boys and 20 girls at each school for each age group. The same tests were given to 80 twelve year old children, 40 boys and 40 girls from Intermediate Normal School.

TABLE I

TESTING PROCEDURE

	Awapuni School		Roslyn School		Intermediate Normal School		
Ages of children	Male	Female	Male	Female	Male	Female	Total
5 year olds	20	20	20	20	-	-	80
8 year olds	20	20	20	20	-	-	80
10 year olds	20	20	20	20	-	-	80
12 year olds	-	-	-	-	40	40	80
Structured attribute blocks	60	60	60	60	40	40	320
Unstructured arrays	60	60	60	60	40	40	320

Footnote:

Palmerston North children progress into the intermediate school system for their last two years at primary school, and the twelve year olds were drawn from the Intermediate Normal School.

TESTING PROCEDURE - PRETESTING

In order to test the hypotheses outlined above, two tasks were devised, one using an array of 30 familiar household objects, and one using "Invicta" attribute blocks. In carrying out the task subjects were simply instructed "Here are some things, you sort them for me". These tests were administered to 70 five year olds in new entrants classes at Hokowhitu and Central Normal Schools. Difficulties encountered related largely to language and to interpretation of reasons for groupings formed. As a result of this it was decided to record verbal responses during the testing sessions. No difficulties were encountered with 20 adult subjects who took the pretest.

TESTING PROCEDURE

For the purposes of the present study, two tests were devised, one using "Invicta" attribute blocks, and the other using an array of 30 familiar objects. In order to overcome bias, the tests were alternatively administered so that every second subject was given the attribute block test first.

Before testing commenced each child was given a few minutes familiarization with the materials. Infant maths procedure was followed so children were seated on the floor with the tester, and materials spread on the mat in a random fashion. Older children were seated at a table. To encourage free sorting, instructions were minimal and the children were encouraged to question and to talk as they wished. To ensure relaxed sorting behaviour, no time limit was imposed. Subjects were encouraged to handle and explore material freely, and testing ceased when the subject considered the task was completed. As might be expected, older children were faster on the tests than five year olds. While there was considerable variation across the groups, five year olds performed the tasks in about half an hour and eight year olds required about 20 minutes. Some ten and twelve year olds completed in ten or fifteen minutes. Before either test was started the child was given a period of adjustment so that he might feel comfortable with the tester, the camera, the tape recorder, and any other aspect of the test situation.

STRUCTURED MATERIALS

Invicta attribute blocks

The tester spread the attribute blocks in front of the child and asked, "Have you seen these blocks before"? Picking up a large thick red circle the tester asked, "Look at this block. Run your finger round the top of it. What do you call things that are shaped like that"? Subjects generally answered, "A circle" or "A round". Tester, "Good, can you find me another circle (round)"? The tester still holding the original circle, picked up a small thick red circle and asked, "What is the difference between this circle (round) and this circle (round)"? Subjects generally give a size response, "Good". The tester (still retaining the original circle) then picked up a large thin red circle and asked, "Can you now tell me the difference between this circle (round) and this circle (round)"? Subjects responded variously, using such terms as thick, fat, thin, and skinny. Some used their hands to demonstrate the difference in dimension. Any response was accepted. The tester then asked, "Do you know what colours we have here"? Most subjects answered correctly but a few five year olds failed to verbalize colours correctly. All responses were acceptable since the tester was concerned to give the child a sense of confidence in his manipulation of the materials, and to provide a permissive atmosphere fostering free sorting behaviour. Children were not asked to name shapes at this stage, their ability to do so emerged later when they explained their groupings.

The tester then continued, "Good, I can see you know a lot of things about these blocks. Now I would like you to sort them for me, put the ones that go together (that are alike), together. There is no right or wrong way of doing this, just make some groups for me please". Children's questions were answered but no criteria were given or grouping done. A few children asked, "Is this right? (what you want?)". They were encouraged to continue as they were. Children who asked this particular question were in fact forming groups. Those who were making patterns or figural arrangements were generally too absorbed by the appearance of the blocks, and very young subjects who were sorting singly did not ask, perhaps from uncertainty, or it may not have occurred to them to do so.

When the subject completed the task, the tester asked, "Tell me what you have done?"), and sometimes, for additional information, "Tell me why you put these together"? Care was taken not to imply sorting error. All responses were recorded on tape or on card, and the grouping arrangement photographed.

UNSTRUCTURED MATERIALS

An array of thirty objects

The tester placed the array of objects in randomized order in front of the child saying, "Do you know what all these things are"? Some children pointed to objects such as the magnet stop, small glass vial, or the piece of polystyrene. These were explained as being, "A magnet, a glass tube, or a piece of plastic". The tester then said, "Here are some things, please sort them for me, put the things that go together, (that are alike), together". The same procedure was then followed as for the structured materials. On completion of the task the tester then asked, "Tell me what you've done"?, pointing to each group. Recording was done as the child explained the reasons for each grouping and then the arrangement was photographed. See Appendix 1 for record card format.

TABLE II

MATERIALS USED

Structured materials - 1 set "Invicta" Attribute Blocks

SHAPE	Round	Square	Triangle	Oblong	Hexagon
THICK	"	"	"	"	"
THIN	"	"	"	"	"
LARGE AREA	"	"	"	"	"
SMALL AREA	"	"	"	"	"
RED	"	"	"	"	"
BLUE	"	"	"	"	"
YELLOW	"	"	"	"	"

Unstructured materials - Array of thirty objects

1 cotton reel
1 yellow plastic detergent top
1 white plastic toothpaste top
1 red plastic toothpaste top
1 cork bottletop
1 white irregular oblong plastic polystyrene
1 white square plastic lego block
1 red and white plastic oblong lego block
1 red and grey plastic lego wheel
1 small red plastic counter
1 silver-embossed metal button
1 copper penny
1 pink plastic bead
1 silver metal knucklebone
1 green plastic oblong transparent perspex (glass)
1 silver oblong metal magnet stop
1 silver-diamente ring
1 silver metal scissors
1 black metal toy motorbike and sidecar
1 cloth flag coloured red, white and green
1 yellow rubber balloon
1 yellow wax birthday-cake candle
1 small clear-glass vial
1 cream plastic man
1 grey plastic kangaroo
1 brown plastic crocodile
1 blue plastic clothespeg
1 blue plastic pencil sharpener
1 blue plastic bus
1 green plastic boat

STATISTICAL PROCEDURES USED TO ANALYSE DATA

Responses for the array material were recorded as group responses i.e. colour, shape, size etc., responses from all five year-olds, and colour, shape, size etc. responses from all eight year olds. The chi square tests for independence in a contingency table was applied using frequency counts.

Let pi be the probability of being group i
Let pij be the probability of group i and response j

Ho : pij = pi x p_oj for all i,j

H_A : pij $\neq$ pi x p_oj for some i,j

Using the intuitive estimate $\frac{ni}{n}$ and $\frac{ni}{n}$ for the probabilities pi and pj respectively ... it can be shown under the Ho (null hypothesis) that the expected frequencies are given by

$$npij = npi^{\bullet}p_{o}j = \frac{n^{\bullet}n_{o}j}{n} \cdot \frac{ni}{n}$$

$$= \frac{ni^{\bullet}n_{o}j}{n}$$

for example in the table for functional response

TABLE III

FUNCTIONAL RESPONSE

Groups	USE	Other	
5 year olds	31 (100.89)	(1007.10) 1077	1108
8 year olds	13800 (68.110)	610 (679.89)	748
	169	1687	1856

The expected frequency of five year old response to use, 100.89, is obtained by multiplying the totals of all five year olds by the total number of responses and dividing by the grand total, 1856.

i.e. $$\frac{ni \times n_{o}j}{n} = \frac{1108 \times 169}{1856}$$

This can then be compared with the observe value nij using the test statistic

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \left\{ \frac{(nij - ni.n.j/n)^2}{ni.n.j/n} \right\}$$

which in this case can be modified to

$$\sum_{i=1}^{K} oi = n = \sum_{i=1}^{K} ei.$$

The probability of obtaining a more extreme value for the test statistic than the one observed is found from tables of chi-square, and if this probability is too low (less than 0.05), then Ho is rejected in favour of H_A.
The Burroughs B6700 SPSS statistical package for the Social Sciences was used to analyse data using the minimum deck, fastabs and statistics card Chi Square and Contingency Coefficient for analysis of data.

ANALYSING THE DATA

The information obtained from testing was inspected carefully and grouping behaviour categorized in various ways. Thus each child's responses were analysed in terms of grouping criteria - colour, shape, size, material and so on, and the frequencies of responses examined. The data was inspected for other information that it might yield. Differences in sorting techniques such as grouping by flat arrangements, towers, heaping materials or care in matching edges of blocks, were noted. Some children tended to spread their groups while others produced a more compact arrangement; linear arrangements were common, vertical and building uncommon. Information relating to hypotheses was sought and categorized, and frequency counts made of all apparently relevant data.

From an inspection of these results it was decided to utilize the Burroughs B6700 SPSS programme to analyse some of the data and to treat other relevant information descriptively. Data analysed by the computer was dealt with under headings as a. Personal information, and including the independent variables. b. Grouping information including the dependent variables such as numbers and groups formed, criteria, Sorting behaviour and Logic. c. Attribute blocks and array materials - including some independent variables. Appendix 3 sets out coded information.

a. PERSONAL INFORMATION

This included such things as age, sex, school, pre-school attendance or not, family size, position in the family, and parent occupation. Position in the family was coded as oldest, middle, or youngest. For parent occupation the Elley-Irving Socio-economic Scale was used.

1. Group 1 High professional and administrative work. (Composed of school teachers except for two veterinarians and other professionals.)
2. Group 2 Lower professional, technical and executive work.
3. Group 3 Clerical and highly skilled.
4. Group 4 Skilled work.
5. Group 5 Semi-skilled repetitive work.
6. Group 6 Unskilled repetitive work.
7. Group 7 Farming.
8. Group 8 Miscellaneous. (Composed largely of solo parents and pensioners, who list no employment.)

New Zealand Journal of Educational Studies. Vol. 7 (2): 153-167 Nov. 1972. Elley W.B. and Irving J.C., "A socio-economic index for New Zealand based on levels of education and income for the 1966 Census".

Information concerning parent occupation was obtained from school records and was sometimes difficult to interpret from such statements as "Army", "engineer", "Railways", or named firm without specific occupation. Table IV lists numbers in each occupation category for each school, and it may be seen from this that the two populations are remarkably similar in terms of socio-economic background.* Other independent variables included family, age, sex, and educational background.

TABLE IV

PARENT OCCUPATION

Occupation Category	School					
	Awapuni		Roslyn		Intermediate Normal	
1	8	6.6%	7	5.8%	17	21.2%
2	18	15%	13	10.8%	25	31.2%
3	19	15.8%	26	21.6%	10	12.5%
4	38	31.6%	43	35.8%	10	12.5%
5	22	18.3%	21	17.5%	7	8.75%
6	5	4.1%	7	5.8%	5	6.2%
7	2	1.6%	0	0	1	1.3%
8	8	6.6%	3	2.5%	4	5%
	120		120		80	

b. GROUPING INFORMATION

Numbers of groups

Aims to measure discrimination and differentiation, and to search for age-related differences. The larger the number of groups formed (and hence the fewer objects per group), the greater the differentiation required. Correspondingly, the smaller the number of groups formed (and hence the more objects per group), the greater the discrimination required.

In the case of arrays, the materials permitted from one to thirty groups to be formed. Attribute blocks sets contain sixty blocks, but initial counts showed few children formed more than thirty groups, so category 31 consisted of groups of more than thirty, mainly singles arrangements. Frequency counts showed that grouping behaviour maintained a

* Intermediate normal school draws from a population with a higher proportion of professional families.

progression from the many groups produced by five year old subjects, to proportionately fewer groups formed by eight, ten and twelve year olds. Of particular interest is the pairing or one-to-one matching behaviour observed in about 31% of five year olds and still a prominent form of grouping in 10% of eight year olds, in 9% of ten year olds and 4% of twelve year olds. Data concerning number of groups for each individual was coded as 1-30 (Arrays), and 1-31 (Attribute Blocks).

Criteria used

The perception of similarity and the grouping of items is an individual response. In the case of the Invicta blocks, attributes of the stimulus material set constraints on the range of possible intellectual operations, whereas the arrays provided a greater diversity of attributes which permitted a more varied basis for grouping.

It was hypothesized that the criteria employed as the basis for grouping would vary with the age of the subjects, and that five year old children will tend to form groups on the basis of a single criterion i.e. single attribute, while eight, ten and twelve year olds would tend to form groups on the basis of several attributes or criteria. It was further hypothesized that the stimulus objects themselves would be strong determinants of the grouping criteria employed. To test these hypotheses responses were coded according to whether subjects used one, two or three-plus criteria as the basis for their groups in arrays and attributes. Where a single criterion was chosen it was placed under one of the following headings by which the criteria are defined.

1. Descriptive

The response given to explain the basis of the grouping as in the simple naming of objects or the use of a single term to describe a group. i.e. "animals" for array objects kangaroo and crocodile, "tops" for objects toothpaste tops etc., or "blocks" for lego toy blocks. Single objects named as "bus" or "candle" or "scissors", were also placed under this heading.

2. <u>Material</u>

Responses in this category include such terms as "plastic", "steel", "metal", "all silver", "wood", "material", or "stuff". A term such as silver presented difficulties in interpretation for it could be considered as a descriptive, a material, or a colour response. The decision concerning exact placement then became contextural, both in terms of contents of particular groups, and the relationship between groups. Thus if a child forms six groups of arrays in which colour is the criterion used, the term silver here may be considered as a colour code. If scissors, button, and bike appear together labelled as "silver", the response is considered to mean "metal".

3. <u>Use</u>

Included within this heading are all those responses which may be considered as equivalent on the basis of use or function of the items - where one considers what they do or what can be done to them. Such statements as "to ride on", "they can move", "make a noise", "can turn them on", or "have them at birthdays", are all coded as referring to use.

4. <u>Weight</u>

A few children selected on the basis of this criterion and when they did, they generally responded by feeling the weight of each object before placing it in a particular group, and then referring to these groups as being "heavy" or "light" things.

5. <u>Texture</u>

Responses in this category were not common and where they appeared, tactile behaviour usually preceded placement of objects, or some verbal statment such as "they've all got bumps", made the intention clear.

6. <u>Other</u> i.e. Not codable under other categories

Is exemplified by such verbal statements as "things you can see in the dark" "Australian", or "alone", "things left out", "won't fit", "cheap", or "empty".

7. Shape

This was a common choice for all age groups and is a basic attribute of the Invicta blocks. Responses such as "round things", "rectangles", "all squares", or "they're the same shape", were common shape equivalence responses. One eight year old, two ten year olds and some twelve year olds distinguished between disc, sphere and cylinder shapes, the rest used the generic term "round". The dimension length, was included in the shape category because statements like "these are long things", referring to boat, bus, scissors, were obviously referring to shape. The length dimension was not included with size, that term being reserved for responses referring directly to size as "big" or "little".

8. Colour

This was an important equivalence category for young subjects. In the Invicta blocks this attribute is coupled with a thick - thin dimension, and where subjects simply formed pairs, these were categorized as thick - thin. Colour was used in coding where it was named and used consistently as an obvious basis for grouping i.e. "all triangles - blue, red, yellow", "all circles - blue, red, yellow", "all rectangles - blue, red, yellow", or "all large red and all small red", "all large blue and all small blue", "all large yellow and all small yellow".

In the arrays, subtler colour categories presented difficulties for some subjects. Was the pink bead to go with red objects or to remain alone as a separate category? Was the cream-coloured man to be placed with the yellow balloon, the white objects, or the fawn? Could the grey kangaroo go with the silvery metal things? Where the child was clearly forming groups with colour as the sole basis for classification decisions were made accordingly and colour groups clearly named, or he might decide to change and use some criterion other than colour i.e. material shape, etc.

10. Size

This dimension was used to code where it was clearly specified as size (e.g. "all little tiny small things", "all big fat large") or where it appeared as a consistent basis for grouping (i.e. all large shapes below with all small ones above or immediately adjacent for attribute blocks).

11. Thick and thin

Terms such as thick and thin, fat and skinny were seldom used for array groups (1%), but this dimension was a basic attribute for the blocks. Some children who were unfamiliar with the blocks became fascinated on discovering this as a consistent dimension, and it is a frequent named choice as the basis for pairing blocks.

12. Not applicable

Some children were either unable or unconcerned to form groups. A number produced patterns or fantasy arrangements to which grouping criteria did not apply, these were placed under this heading. A few children placed their materials in heaps, the basis for which neither they nor I could explain. Syncretic heaps of this nature were also coded here.

Sorting behaviour and logic

Subjects responded in a variety of ways when asked to form groups. The rarest and most immature response appeared to be placing objects in unexplained heaps - syncretic heaps to use Vygotsky's term. Some subjects placed each object separately with no attempt at grouping - nevertheless close inspection revealed some interconnectedness in the placing of the objects so that one might observe a large red triangle followed by two large blue triangles, then two small blue circles, and then a large yellow circle followed by five yellow rectangles, and so on. This type of response was labelled chaining. Close to, and sometimes overlapping chaining was the commonly observed pairing response, where each object was picked up separately and another placed beside it because of shared common property or properties. Finally "true" grouping appears where subjects place all objects logically according to explained criteria which include all the objects within the specified criterion. Where the child presented fantasy arrangements (e.g. cows in a paddock) or where figural arrangements appeared (e.g. groups of people, kites, or rockets were built), these were coded as "fantasy other", since they were not codable under other categories.

The coding categories for sorting behaviour were:
1. True grouping 2. Pairing 3. Chaining 4. Syncretic heaps
5. Figural and fantasy arrangements - other.

Linked with the progression in sorting type is a similar developmental progression in the logic basic to equivalence perception and classificatory grouping. It was hypothesized (p.19) that five year old children will more typically tend to form groups which lack logical criteria as their basis. It is further hypothesized that more eight, ten and twelve year olds will tend to form groups on the basis of a single criterion i.e. a single attribute (p. 19).

Frequency counts indicated that most ten and twelve year olds, many eight year olds and some five year olds were able to group according to several criteria at once as was clearly evident from Figures 2-12,15. The kind of grouping illustrated would be coded as "total complex". A simpler type of one to one correspondence occurred with many of the paired groups i.e. grouping by a single criterion, and this was coded as "total simple". (i.e. 2 tops, 2 plastic toys, 2 rectangular shapes, 2 more plastic objects.) Thus plastic might occur in three separate groups. The term "shifting logic" applied where illogicality occurred, or where the ability to group by chosen criteria appeared unstable. Some children formed 1-5 groups usually in pairs, and arranged the rest as singles. Shifting logic appears to be naturally linked with the chaining response. Children who produce fantasy and figural arrangements and syncretic heaps were coded as being "other". Categories for logic were 1. "total simple" (paired) 2. "total complex" (groups) 3. shifting logic 4. fantasy, other.

c. <u>ATTRIBUTE BLOCKS - Sorting criteria</u>
Initial scanning of frequency counts of criteria employed indicated differences in preference for colour on the part of five year olds and for shape on the part of eight, ten and twelve year olds. Certain developmental trends were also evident for other criteria.

The criterial responses on attribute blocks were placed in categories as defined under grouping criteria (these pages 30-33). They were coded for computer analysis for each subject under one of the following headings:

1. Colour alone
2. Colour, shape, thick/thin
3. Colour, size, thick/thin
4. Colour, shape, size
5. Colour, thick/thin
6. Colour, shape, size, thick/thin (all attributes)
7. Shape alone
8. Shape, thick/thin
9. Shape, size
10. Shape, size, thick/thin
11. Size alone, and size thick/thin
12. Thick/thin alone
13. Singles, fantasy, figural arrangements, syncretic heaps

ARRAYS - Sorting criteria

Responses for the array material were classified as group responses (i.e. all five year olds or all eight year olds) rather than as individual responses. The array grouping responses were placed in categories as defined under grouping criteria (these pages 30-33). Some children were unable to explain the basis for the groups formed and where the criteria were not obvious, the responses were recorded as unexplained. The chi-square test for significance was applied using the frequency counts.

RESULTS ANALYSED IN TERMS OF HYPOTHESES

As has been shown by Piaget (1964), Bruner et al (1966), grouping shows a progression in growing complexity in the number of variables involved and the kinds of groups formed, which seems to relate to maturing thinking abilities.

1. Hypotheses relating to the numbers of groups formed

The first research question to be investigated concerned the numbers of groups formed by children of different ages. The research hypothesis was formulated to state that five year old children would tend to form more groups as pairs or singles arrangements with both array materials and attribute blocks, while eight, ten and twelve year olds would tend to form fewer groups with more objects within each group. TABLE V (Blocks), and TABLE VI (Arrays), show the spread of groupings for five, eight, ten and twelve year old children.

There is a significant difference between five, eight, ten and twelve year olds for the numbers of groups formed (1-31) with blocks of 0.0001, and an even greater significant difference of <0.0001 with arrays on the numbers of groups formed (1-30).

While this evidence shows significant differences between five, eight, ten and twelve year old children on the numbers of groups formed, the distribution of groupings is of particular interest. A comparision of attribute blocks and arrays on the numbers of groups formed, shows a greater tendency to clustering for attribute blocks than for arrays. This response may be due to constraints imposed by the stimulus materials. Colour, size, shape and thick/thin combinations tend to result in clustering at groups 3, 5, 10, 12, 15, 20 and 30.

TABLE VII frequency counts showed that groupings of older children tended to spread more evenly across the total possible numbers of groupings while the distribution for five year olds showed a tendency to clustering. Of particular interest is the pairing or side by side response of five year olds which shows as a clustering around the 13-16 groups with arrays, and 29-30 groups formed with attribute blocks. Non-grouping or simply arranging blocks or arrays singly also shows up in children's grouping as clustering at 30 groups for arrays or at 31 plus groups for the blocks. (TABLES V, VI and VII).

TABLE Va

Number of groups formed - blocks

Age	Group Number 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	23	24	25	26	28	30	31	Total
5 year olds	0	9	1	5	1	2	2	1	14	3	2	1	0	4	0	0	0	4	0	0	1	1	0	0	0	19	10	80
8 year olds	5	4	1	5	1	0	1	1	8	2	3	1	1	7	1	2	0	18	4	1	0	0	1	1	1	9	2	80
10 year olds	5	6	3	12	3	1	1	0	8	0	1	0	1	10	1	1	0	21	0	1	0	0	0	0	0	5	0	80
12 year olds	7	9	5	8	1	1	0	3	5	1	8	0	0	5	0	0	1	25	0	0	0	0	0	0	0	1	0	80
TOTAL	17	28	10	30	6	4	4	5	35	6	14	2	2	26	2	3	1	68	4	2	1	1	0	1	1	34	12	320

Significance $= > 0.001$

75 degrees of freedom

TABLE Vb

Attribute blocks - clustering of groups

Attribute	Group Size	Clustering N =
Colour alone	3	28 in 320
Shape alone	5	30 in 320
Colour and size	6	6 in 320
Shape and size	10)	35 in 320
Colour, size, thick/thin	10)	
Colour size, thick/thin	12	14 in 320
Shape size, thick/thin	15	26 in 320
Shape, size, thick/thin	20)	68 in 320
Thick/thin and size	20)	
Pairing thick/thin	30	34 in 320

TABLE VI

Number of groups formed - Arrays

Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	22	23	25	26	27	28	29	30	Total
5 year olds	2	1	3	3	6	3	4	1	4	4	3	3	6	13	4	2	0	0	1	0	2	1	1	1	1	1	10	80
8 year olds	5	3	5	6	8	9	8	5	3	4	3	5	1	8	2	1	0	0	1	2	0	0	1	0	0	0	0	80
10 year olds	1	0	2	11	7	15	13	3	5	4	2	2	5	5	0	2	2	1	0	0	0	0	0	0	0	0	0	80
12 year olds	2	4	12	10	13	6	11	8	3	3	4	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	80
TOTAL	10	8	22	30	34	33	36	17	15	15	12	10	12	29	6	6	2	1	2	2	2	1	2	1	1	1	10	320
			/	/	/	/	/	/	/	/	/	x	x	x	x													

Group Number

$\underbrace{x \quad x \quad x \quad x}_{\text{pairing}}$

Singles

Significance = $>$0.001

75 degress of freedom

TABLE VII

Number of groups formed - Age

Age	Arrays No. of groups 13 - 16	29 - 30	Attribute Blocks 29 - 30	30 plus	Immature Grouping	Mature Grouping	Total	% Immature Grouping
5 year olds	26	11	19	10	66	94	160	41% immature grouping
8 year olds	16	0	9	2	27	133	160	17.0% immature grouping
10 year olds	12	0	5	0	17	143	160	11% immature grouping
12 year olds	3	0	1	0	4	156	160	2.5% immature grouping
TOTAL	57	11	34	12	114	526	640	

These immature responses of pairing or singles arrangements are thus shown by 40% of five year olds and they are still present as 17% of the grouping behaviour of eight year olds, as 11% in ten year olds and only 2.5% in twelve year olds. Thus singles arrangements and pairing responses would seem to indicate a developmental pattern which is uncommon in twelve year olds and less common in eight and ten year olds than in five year old children. TABLE VIII shows frequency responses to array materials recorded for all five year olds and all eight year olds, rather than as individual response. The response total for five year olds (1108) is higher than for eight year olds (748). This may also be related to the tendency to group objects side by side in pairs which appears in the sorting of more five year olds than eight year olds. Eight year olds tend to place more objects in a group.

2. Hypotheses relating to inclusive discrimination

The second question concerned the observed tendency of some subjects to form few groups each with many objects ("Inclusive discriminators"), and of other subjects to form many groups with few objects in each ("specific discriminators").

It was hypothesized that there would be no significant difference between the proportion of five year olds who were inclusive discriminators and the proportion of eight, ten and twelve year olds who were inclusive discriminators. It may be seen from TABLE IX that categorization in terms of few or many groups formed does not show significance for each of the independent variables with either blocks or arrays, and it is the only dependent variable scanned which shows no significance with age. The null hypothesis is thus supported.

It was also hypothesized that there would be no significant difference between the proportion of boys who were inclusive discriminators and the proportion of girls who were inclusive discriminators. Inspection of the data showed distributions of groups formed by boys and girls with either material as very similar. The data was also analysed in

TABLE VIIIa

Arrays - Response frequency

Age	Descriptive	Shape	Size	Colour	Material	Use	Weight	Texture	Fantasy Other	Unexplained	Response Total
5 year olds	89 8%	121 11%	25 2%	179 16%	103 9%	31 3%	14 1.2%	13 1%	104 9%	429 39%	1108 99%
8 year olds	131 17.5%	166 22%	34 4.5%	42 6.1%	62 8.2%	138 18.4%	13 2%	9 1%	40 5.3%	113 15%	748 100%
10 year olds	135 18%	115 16%	3 0.4%	105 14%	114 15%	132 18%	19 3%	21 3%	0	50 7%	738 95%
12 year olds	93 15%	98 16%	4 0.6%	52 8%	157 25%	118 19%	14 2%	9 1.4%	14 2%	14 2%	616 92%

TABLE VIIIb

Arrays - Chi-Square Results

Age	Descriptive	Shape	Size	Colour	Material	Use	Weight	Texture	Fantasy Other	Unexplained
5/8 year olds	0.001	0.001	0.005	0.001	<0.01	0.001	<0.01	NS	0.005	0.001
8/10 year olds	NS	0.005	0.005	0.005	0.005	NS	NS	NS	0.005	0.005
10/12 year olds	NS	NS	NS	0.01	0.005	NS	NS	NS	0.005	0.005
12 year olds										

terms of few (three or less groups), and many (more than three groups) formed. The intention here being to look at possible variables relating to instances where subjects formed few groups. Pretesting had led the writer to suspect that this might occur more frequently with boys, and also that it might occur more frequently with older than with younger children. TABLE Xa below shows the distribution of individuals who formed few groups in the sorting tasks.

TABLE Xa

Inclusive Discriminators - Blocks or Arrays

Age	Male	Female	Total	%
5 year olds	6	4	10/80	12½%
8 year olds	10	5	15/80	19%
10 year olds	2	7	9/80	11%
12 year olds	9	8	17/80	21%
Total	27	24	51/320	16%

As may be seen from TABLE Xa inclusive discrimination occurred for about 16% of this population with no clear trends evident either in terms of age or sex. The null hypothesis was thus confirmed.

It was further hypothesized that the tendency of individuals to demonstrate inclusive discrimination would not differ significantly from array stimulus material to attribute stimulus material. The null hypothesis was not supported by the data in TABLE Xb where a total of 44 subjects showed inclusive discrimination in sorting attribute blocks and 18 subjects in sorting array materials.

TABLE Xb

Stimulus Material and Inclusive Discrimination

Age	Attribute Blocks	Arrays
5 year olds	9	3
8 year olds	9	8
10 year olds	11	1
12 year olds	15	6
Total	44	18

Since colour sorting of attribute blocks produces three groups, it was suggested that this variable might bias these results and increase the numbers of inclusive discriminators sorting attribute blocks.

Wallach & Kogan (1965) refer to sex differences emerging with girls tending to form more groups with fewer objects in each. The results from the present study do not support such findings.

TABLE Xc shows the results of increasingly rigorous test constraints, where only those individuals who were inclusive discriminators in both tests were included.

TABLE Xc

Inclusive Discriminators - Blocks and Arrays

Age	Attribute Blocks	Arrays	N = 320 3% population
5 year olds	1	0	
8 year olds	2	1	
10 year olds	0	0	
12 year olds	4	2	Total
	7	3	10

More males now appear as inclusive discriminators. While the numbers are too small to permit conclusions to be drawn from the data, the trend should be noted.

From the three hundred and twenty subjects tested, fifty-one children showed inclusive discrimination and only ten of these (seven male and three female) did so with both blocks and array materials. It may be seen from TABLE IX that categorization in terms of few or many groups formed, does not show significance for any of the independent variables for either blocks or arrays, and it is the only dependent variable scanned which shows no significance with age. (P. 44)

TABLE IX

Showing Significance for Independent and Dependent Variables for all age Groups

Dependent Variables	Independent Variables						
	Sex	Age	Family Size	Position in Family	School Awapuni Roslyn Inter-mediate Normal	Pre-school Attend-ance	Parent Occupation
Attribute Blocks Group Nos. 1-31	NS	>0.001	0.05	0.05	NS	NS	NS
Arrays Group Nos. 1-30	NS	>0.001	NS	NS	NS	NS	NS
Attribute Block Criteria 1 - Many	NS	>0.001	NS	NS	NS	NS	0.05
Array Criteria 1 - Many	NS	>0.001	0.02	NS	NS	NS	NS
Attribute Blocks Single Criterion	NS	NS (0.06)	NS	NS	NS	NS	NS
Arrays Single Criterion	NS	>0.001	NS 0.06	NS	NS	NS	NS
Attribute Blocks Criteria 1-13	NS	>0.001	NS (0.06)	NS	NS	NS	.03
Attribute Blocks Categorizer (Ind. Discrim.)	NS	NS	NS	NS	NS	NS	NS
Arrays Categorizer (Inclusive Discrim.)	NS 0.0608 0.0894	NS	NS	NS	NS	NS	NS
Attribute Blocks Logic	NS	>0.001	NS	NS	NS	NS	.01
Arrays Logic	NS	>0.001	NS	NS	NS	NS	NS
Attribute Blocks Sorting & Arrangement	NS	>0.001	NS	NS	0.02	NS	NS
Arrays Sorting & Arrangements	NS	>0.001	NS	NS	0.04	NS	NS

3. Hypotheses relating to grouping criteria

The third cluster of hypotheses was concerned with criteria used as the basis of grouping. It was hypothesized that eight, ten and twelve year olds would typically use three or more criteria as the basis for their grouping. As may be seen from TABLE XIa eight, ten and twelve year olds more frequently used "three or more criteria" as the basis for their grouping. On the other hand, category 4 "fantasy, other (nil)" responses were more frequently given by five year olds. TABLE XIb shows significance between age groups on the basis of criteria used. (Footnote.)

TABLE XIa

Number of criteria used

Age	Attribute blocks - Criteria				Arrays - Criteria			
	1	2	3	4	1	2	3	4
5 year olds	20	26	18	16	21	6	27	26
8 year olds	14	24	36	5	21	18	37	4
10 year olds	20	19	41	0	9	17	54	0
12 year olds	27	29	23	1	21	17	41	1

TABLE XIb

Number of criteria used - Significance

Age	Attribute blocks	Arrays
5/8 year olds	0.005	>0.001
8/10 year olds	NS	0.005
10/12 year olds	<0.01	0.05
Significance for all groups	>0.001	>0.001

As may be seen from TABLE XIa the differences between five, eight, ten and twelve year olds were very highly significant for blocks beyond

Footnote:

Category 3 = 3 or more criteria.

0.001 level, and for arrays beyond the 0.001 level which is also very highly significant. The number of criteria chosen does not, however, show significance for any other of the variables examined.

Pretest data showed that a few subjects named all their groups by a single criterion such as colour, thus indicating a strong preference for the chosen criterion. Grouping criteria are outlined on pages 30-33. Those cases where subjects used a single criterion such as colour, size, and so on, were examined for developmental trends which might be interpreted in terms of age.

All groups showed preferences for shape, colour and material. More five year olds selected shape and colour as a single criterion for grouping, while eight, ten and twelve year olds showed a preference for use categories, and twelve year olds for material as a basis for grouping arrays (TABLE XII).

TABLE XII

Grouping by a Single Criterion

Age	Material		Use		Shape		Colour		Thick/Thin	
	Block	Array	Block	Array	Block	Array	Block	Array	Block	Array
5 year olds	1	5	-	-	11	5	8	10	-	-
8 year olds	-	6	-	3	4	5	2	4	6	-
10 year olds	-	-	-	2	8	-	6	6	6	1
12 year olds	-	16	-	4	10	-	9	1	7	-
	1	27	0	9	33	10	25	21	19	1

The next hypothesis stated that five year olds would group objects more frequently than would eight, ten or twelve year olds on the basis of responses which could be classified as affective or perceptible, and that eight year olds would group more frequently by functional criteria (as defined by Bruner ... "the child may render items as equivalent on the basis of immediate phenomenal qualities such as colour, size, shape on the basis of position in time or space ... and the child may base equivalence on the use or function of items, considering either what they do or what can be done to them ...." Bruner and Olver (1966) p. 71-72). See Bruner et al Studies in Cognitive Growth.

Criteria were categorized from the children's individual responses and these categories are described in p.30-33 of this paper. No affective responses were given. It had been anticipated that responses such as "Because I like them that way" might be used; however, the more prosaic "Because they stick together ... go together" was the most usual response given to justify otherwise unexplained groupings. TABLE VIIIa presents results from frequency responses for array materials, recorded for age of subjects. Responses to array material were classified as group responses (i.e. all five year olds or all eight, ten or twelve year olds), and not as individual responses.

The hypothesis was supported with perceptible responses (colour, size, shape) decreasing from five to twelve year olds. Within the perceptible category, very highly significant differences were noted, with colour being the predominant perceptible criterion choice in five year old grouping. The hypothesis is also supported for functional criteria with an increase in the functionally based use category for eight, ten and twelve year olds. Very highly significant differences appear between five and eight year olds on these grouping criteria. See TABLE VIIIb. Computer results for Attribute blocks also show highly significant results for criterial differences between five and eight year olds, TABLE XIIIb.

TABLE XIIIa

Perceptible and functional responses

Age	Perceptible response (colour, size, shape)	Functional response (use)
5 year olds	325	31
8 year olds	242	138
10 year olds	223	132
12 year olds	154	118

TABLE XIIIb

Attribute Blocks - Criteria Used

Age	Colour	Colour Size Thick/ Thin	Colour Shape Size	Colour Thick/ Thin	Colour Shape Size Thick/ Thin	Shape	Shape Thick/ Thin	Shape Size	Shape Size Thick/ Thin	Size Alone	Thick Thin Alone	Singles Fantasy Figural	Significance
5 year olds	10	1	2	4	5	2	30	7	11	1	1	6	5 & 8 year olds = >0.01
8 year olds	3	5	6	0	3	7	19	7	18	2	6	3	8 & 10 year olds = 0.05
10 year olds	4	3	3	3	13	8	12	3	21	0	7	0	10 & 12 year olds = 0.01
12 year olds	8	7	2	1	4	10	20	4	7	4	6	4	Significance for all age groups = >0.001

It was further hypothesized that five year old children would typically tend to form groups which lack logical criteria as their basis. The data was analysed in terms of "simple" logic (i.e. the ability to sort and sustain chosen criteria in a paired group), "complex or true" logic which is sustained for larger groups often using more than one criterion per group, and "shifting" logic (where grouping by chosen criteria is unstable, or grouping illogical). TABLE XIV, P. 50.

Figures 14a and 14b show sorting behaviour with shifting logic with attribute blocks.

Figure 14a (lower). Here a five year old boy has formed groups mainly by shape, but a single colour set shows the shift in his logic. Note that not all the red blocks are included in his red set. Two of the groups formed include, subsets of large and small, but this strategy is not carried through in the other groups.

Figure 14b (lower). This eight year old boy starts by shape sorting but becomes distracted by other attributes such as colour so that final sorting presents a display with shifts in grouping criteria. While chaining and singles responses show similar changes, this child is more advanced in that he is forming discrete groups.

Figure 14b (upper). This grouping done by an older subject lacks any discernible grouping strategy. Thus he was unable to explain the basis for any of the groups and said that he was not "story-telling" or forming patterns.

Figure 14a (upper). Grouping done by an older subject who stated circles as the basis for her groupings and then decided to change to colour and finally became involved in making patterns.

TABLE XIV

Logic and Age

		Simple Logic	Complex Logic	Shifting Logic	Fantasy Figural
5 year olds	Attribute blocks	21	33	19	7
	Arrays	21	23	28	8
8 year olds	Attribute blocks	5	64	8	3
	Arrays	18	58	4	0
10 year olds	Attribute blocks	5	71	4	0
	Arrays	12	66	2	0
12 year olds	Attribute blocks	0	78	1	1
	Arrays	5	71	3	1

This table shows significance at beyond the 0.001 level for both attribute blocks and arrays. The data shows that more five year olds are prone to shifting logic, while eight, ten and twelve year olds are able to form and sustain complex grouping with a logical basis. The hypothesis is thus supported. Frequency counts showed that none of the thirty-three five year olds nor sixty-four eight year olds who showed complex logical groupings, showed illogical and immature groupings such as singles, chaining or shifting logic with either array or attribute material. The single twelve year old who showed fantasy figural groupings did so on both array and attribute materials. He was an intelligent boy with highly idiosyncratic leanings. Only one of the three "special class" twelve year olds who showed shifting logic did so with both array materials and attribute blocks.

Differences appeared as very highly significant >0.001 level for logic and age between five and eight year olds and five and twelve year olds for both blocks and arrays. Comparisons between eight and ten year olds and between ten and twelve year olds did not show differences which were significant. These findings provide further evidence for the Piagetian theories on the development of logical thinking. Piaget (1964).

No significant differences were observed between the sexes when the logical basis of grouping was examined in terms of sex differences.

4. Hypotheses relating to stimulus material

The fourth question investigated was concerned with the potency of the stimulus material as a determinant of grouping behaviour. It was anticipated that subjects would group structured material such as Invicta Attribute blocks by criteria different from those used to group an array of unstructured material. In order to determine grouping criteria, the individual responses of children were recorded and these were further categorized as described on pages 30-33.

It was hypothesized that five and eight year old children would group structured attribute blocks by different criteria from those used to group an array of unstructured material. It was further hypothesized that individual children would group structured and unstructured material by different criteria. Results showed that no subjects used descriptive criteria for describing block groupings, only one referred to material, and none made reference to use weight or texture in relation to attribute blocks, while the same subjects made use of these criteria in grouping array materials. Shape, size, colour and thick/thin were the chosen criteria for grouping attribute blocks. Since these attributes are inherent in the block set they are probably the determining factor for criteria used to group blocks. The initial hypothesis concerning stimulus objects has been supported. It is also observed that different criteria were used to group array and attribute block materials, and that individual children grouped the stimulus materials by different criteria.

There was no significant difference reported on stimulus materials and criterial choice between the sexes. See TABLE VIII p. 41 and TABLE XIIIb p. 48.

5. Hypotheses relating to sorting behaviour and pattern making

The final research question examined the sorting behaviour in relation to pattern making. Pretests had shown that when asked to group objects, some children produced patterns and figural arrangements, and the present study was seeking for generalized trends. Data interpretation was made difficult because too few children produced fantasy arrangements for any conclusions to be drawn from this. Pattern making emerged strongly, but pattern making and orderly arrangements of blocks were sometimes part of a continuum so that distinctions became indeterminate, and the categorization of them subjective. Thus while it may not be difficult to decide that six towers of blocks arranged in a straight line across the mat is not a pattern, the decision may not be quite so straightforward for a similar arrangement where the six groups are split and arranged as blocks side by side in two lines!

Sorting behaviour was categorized, therefore, according to the type of sorting i.e. whether true groups were formed, or whether subjects produced pairing or chaining responses or syncretic heaps. These latter responses are considered developmentally immature as compared with "true" grouping.

Data concerning fantasy and figural arrangements was coded for computer analysis where the arrangement was clearly indicated, as for example when the subject stated "this is a house" and proceeded to make one, or "this is a man", and a figure was produced. (Figures 16a and 16b show examples of such arrangements.)

It was hypothesized that there would be no significant difference between five, eight, ten and twelve year old children in the number of patterned and figural arrangements produced. Fourteen fantasy and figural arrangements were recorded, eleven from five year olds, and three from eight year olds. TABLE XVII shows sorting behaviour with age and TABLE XVI pattern making with age. Data for TABLE XVI was drawn from frequency counts made from photographs.

TABLE XVI

Pattern making and age

Age	Geometric, pictorial or pattern making	Non-pattern making	N	% pattern making
5 year olds	47	113	160	29.3%
8 year olds	28	132	160	17.5%
10 year olds	4	156	160	2.5%
12 year olds	9	151	160	5.6%

From this data it may be seen that pattern making occurs more frequently in five year olds than in eight, ten or twelve year olds. The null hypothesis is not supported. No significance tests were made since the data is based to some extent on subjective judgment.

Sorting behaviour was computer coded as "true" groups, pairing, chaining, syncretic heaps, fantasy and building arrangements. See figs. 19 to 22 for pictorial examples, also figs. 13, 15-16.

TABLE XVII

Sorting behaviour and age

Age	Stimulus Material	True Groups	Pairing	Chaining	Syncretic Heaps	Fantasy Building & Other	Significance
5 year olds	Blocks	43	20	9	1	7	5/8 year olds
	Arrays	24	29	14	9	4	Blocks >0.001 Arrays 0.001
8 year olds	Blocks	68	8	1	0	3	8/10 year olds
	Arrays	58	21	1	0	0	Blocks NS Arrays NS
10 year olds	Blocks	76	4	0	0	0	
	Arrays	69	11	0	0	0	10/12 year olds Blocks NS
12 year olds	Blocks	77	1	0	0	2	Arrays NS
	Arrays	73	5	1	·0	1	All groups Blocks >0.001 Arrays >0.001

The data for sorting shows very high significance beyond the 0.001 level for all group comparisons. Further inspection of TABLE XVII shows however that the differences are occurring between five year olds and other groups. There is a discontinuation in behaviour between five and eight years rather than the simple progression shown in much of the grouping. These findings are in keeping with those of Inhelder & Piaget (1964) who would interpret them in terms of the child's moving from figural or non-graphic collections to graphic collections in classification.

It was further hypothesized that there would be no significant difference between boys and girls in the numbers of patterned and figural arrangements. TABLE XVIII.

The data produced no significant differences between groups either on overall sorting behaviour or for immature sorting behaviour of boys and girls with blocks or arrays. The null hypothesis was thus supported.

It was further hypothesized that there would be no significant difference between the numbers of patterns and figural arrangements produced regardless of whether the subjects were using attribute blocks or array materials.

TABLE XVIII

Sorting behaviour in boys and girls

	Attribute Blocks		Array Materials	
	Male	Female	Male	Female
"True" Groups	130	134	114	110
Pairing	20	13	32	34
Chaining	6	4	9	7
Syncretic Heaps	0	1	3	6
Fantasy, building, other	4	8	2	3
Total	160	160	160	160

Significance: 0.3696 NS 4 degrees of freedom. 0.8120 NS

TABLE XIX

Stimulus materials and pattern making

Age		Geometric, pictorial pattern making and fantasy	Non-pattern making arrangements	Total
5 year olds	Blocks	37	43	80
	Arrays	10	70	80
8 year olds	Blocks	26	54	80
	Arrays	2	78	80
10 year olds	Blocks	2	78	80
	Arrays	2	78	80
12 year olds	Blocks	7	73	80
	Arrays	2	78	80

TABLE XIX shows a decrease with age in geometric, pictorial, pattern making and fantasy arrangements. However, where pattern making occurs it does so mainly with attribute blocks. The null hypothesis was not confirmed. Seventy-two instances of pattern making occurred with attribute blocks as compared to sixteen instances with array materials.

6. Verbal explanation related to sex and age of subjects

Sex and age differences were investigated in terms of the subject's ability to explain the basis for his or her groupings. Children's verbal responses were recorded, and their explanations noted. TABLE VIIIa shows 39% of unexplained groupings for five year olds as opposed to 15% for eight year olds, 7% for ten year olds, and surprisingly, 2% for twelve year olds. Highly significant differences were found between each age group (TABLE VIIIb). Descriptive responses occurred in 89 five year olds and 131 eight year olds ($p = 0.001$) and thereafter, results were not significant. Data analysis also showed that five and eight year olds gave more perceptible (relating to colour, size, shape) responses, and ten and twelve year old children more functional responses (relating to use and material). TABLE VIII and XIII. No significant differences were recorded for sex, which would seem to indicate that age rather than sex may be operating in children's ability to explain and describe their groupings.

It is interesting to note that while five year old girls appeared to be a little more fluent than boys, the difference was not great and the data was not coded. Nor did there appear to be notable distinctions between Maori and Pakeha children tested, but the former constituted too small a group from which to draw valid conclusions. It was observed that only one child in the 320 failed to verbalize at all, and of the 29 who had difficulty in explaining, ten were new entrants, and 17 of this group showed immature sorting behaviour with chaining response or pairing with shifting logic. Seven of the remaining 12 were either extremely shy or were judged by their teachers to have emotional problems. An additional four children were tested for interest. These were special class or retarded children. Their data was not recorded because they were six years old. These children showed some immaturity in their grouping, but they were able to explain what they had done.

It was further hypothesized that eight, ten and twelve year old boys and girls would show no difference in stating the basis of their grouping. This hypothesis was supported since all of these children were able to explain the basis for their groupings.

A number of factors appeared to be operating to affect the verbal fluency of some subjects. A young child may have difficulty understanding instructions. Within the present study, test instructions call for an understanding of such terms as "group", "sort", and "go together". The child may appear to understand in order to please the experimenter or he may fear giving a "wrong answer". He may acquiesce through lack of concern or interest, or he may not remember. One cannot be sure that when a child is asked to explain the basis for his groupings, that he perceives the required comparisons. Familiarity with the classroom situation would appear to be important. Children from the new entrants' class generally were more shy and ill at ease and took longer to complete the tasks. Personality would seem to be important for some children are more confident and talk more easily than others. These are some of the factors which may operate to affect verbal responses of children in explaining their grouping behaviour.

It was evident from observations of attribute block sorting that some children could group consistently according to logical criteria, and yet be unable to explain what they had done. This finding agrees with that of Mary Nixon (1971). Language at this stage may be a necessary but not sufficient condition for developing classification skills which in the five year old at least, are still strongly perceptually based.

Five year olds generally placed the two animals together, named them as "crocodile" and "kangaroo", or called them "animals". Eight year olds generally named the pair "animals"; many eight year olds and most ten year olds included the man with the two animals and referred to the group as "living things". Similarly the "boat", "bus" and "bike" of the five year old became "things you can ride on" for the eight year olds and "modes of transport" for ten and twelve year olds. Many five year olds had difficulty verbalizing the distinction between size and shape. "Long" could mean "long" or "big". Their perception appeared to be ahead of their verbal ability for it was usually clear from their sorting, which was intended.

The array materials contained a number of circular objects which included a spherical bead, several disc-shaped objects and a number of cylindrical objects. Five year olds referred to them all as "round" or "a circle" and did not distinguish beyond this. Eight year olds might separate discs and bead out, call them "rounds" or "circles", and then include the odd cylinder shapes amongst them. By age ten, children appeared to be more conscious of the disc-cylinder distinction and more selective of these objects; but they still did not sort them perfectly into these categories and they did not verbalize the distinction even when observed to be perceptually aware from their sorting behaviour. Twelve year olds were similar to ten year olds in their sorting of these objects but a few referred to the bead as a "sphere" and placed it with the spherical diamante ring. Two of the twelve year olds who chose shape sorting separated out and named the cylindrical objects as "cylinders".

The hexagonal attribute blocks showed a similar progression in verbalization. Five and eight year olds either did not name it, or asked what it was called and then named it. By ten, a few children could name the hexagon. A number were concerned that they didn't know its name and tried "octagon". One boy tried "octagon", felt this was wrong and then smiled as he succeeded in naming "a stop sign"! Ten year olds from one classroom seemed all to know the hexagon and proceeded to name it, it appeared that they had discussed the shape that morning. The afternoon children from that class had mostly forgotten the name of the hexagon. Virtually all twelve year olds named the hexagon correctly and with confidence. Rectangle square and circle were named correctly by some five year olds and most eight year olds. A few five year olds did not distinguish square and rectangle in their sorting. Some distinguished the two shapes once they began sorting and later verbalized them as "squares" and "long ones". Ten and twelve year olds showed an increase in weight and texture criteria and also in use and material (what objects are made of) categories. Their language reflected their functional superordinate groupings which generally contained more objects per group. Children now described groups as "all plastic", "all metal", "to use about the house", "useless", "oddments", and "things you can see in the dark".

Children's language shows a development with age both qualitatively and quantitatively. Language development appears to parallel grouping behaviour which shows a progression in growing complexity both in the numbers of variables involved and kinds of groups formed. Verbalization appeared to lag behind grouping behaviour in some children which may relate to such factors as perceptual mode and intelligence. Overall the primary school children showed increasing complexity and abstraction in their language development with age.

DISCUSSION AND CONCLUSIONS

The present study sought to investigate some aspects of classification which might demonstrate developmental trends in children's thinking. The results of the investigation support the general thesis that there is a relationship between age of subjects and maturing classificatory abilities.

1. Data from the S.P.S.S. analysis showed no statistically significant effects for any of the independent variables investigated with the exception of age (TABLE IX, P. 44). Thus sex, family size, position in the family, school, pre-school attendance and parental occupation did not produce significant effects with any of the dependent variables.

   Age-related differences have been reported in detail pages 36 - 58 and age differences are also referred to in the following sections of this discussion. One finding of interest which emerged from the data was the amount of variability within age cohorts. Five year olds particularly, produced a range of sorting behaviour from immature syncretic heaps with illogical sorting to complex sorting which showed an apparent ability to deal with a number of variables at once. Figures 15a and 17a (lower) are photographs of arrangements which were produced by five year olds. Eight year olds also showed considerable variation in grouping behaviour, but ten year olds tended to produce stable, logical groupings and the range in their behaviour was not as marked. Twelve year olds again showed a great variation in their grouping behaviour.

   Throughout the work a pattern seemed to emerge showing increasingly logical sorting, a decreasing number of pattern, figural and fantasy arrangements, and a decrease in unexplained groupings; then suddenly with some of those older children, a "breaking of the pattern" appears (one would expect no "unexplained responses" and fewer illogical immature sortings in twelve year olds -

TABLE VIIIa and XIV). By ten, children seemed to have lost the tendency to building and fantasy arrangements, so why did they reappear in odd twelve year olds? One might dismiss the reappearance as a statistical oddity were it not for the fact that a number of adults showed similar groupings. The twenty adults tested were professional men or women and students. Two of these adult subjects produced illogical sorting and one of these was unable to explain what he had done (Figure 14b upper photograph). Another adult subject produced a fantasy building arrangement which she described as "a garden with stepping stones". Pattern making appeared strongly in the two problem solvers who set themselves problems involving all attributes in radiating circles (Figures 17a and 17b upper photographs). Similar figural problem solving occurred with two of the five year old children and in two of the twelve year olds, it did not occur at all among the 160 eight and ten year olds. The apparent uniformity of most eight and ten year old groupings may be related to the "concrete" and "factual" thinking so widely reported in children of these ages. (Vygotsky, (1966), Bruner et al (1966), Inhelder & Piaget (1964) and others.) Free sorting tests of this nature provide opportunities for intellectual projection and one might hypothesize that the more perceptually based five year old is not yet tied to logical sorting, while the older subject who has reached the stage of formal operational thinking, has achieved the ability to see beyond the immediate confines of the material, so that in a different sense his thinking is fluid. The apparently illogical sorting of some older subjects remains unexplained.

Differences in <u>grouping strategies</u> also appear to be age-related. The five year olds tended to form groups which were perceptually based, often as things took their fancy in a planless way. An object would be picked up and a second put down to go with it. "... The kangaroo goes with the crocodile 'cos they're animals" or, "The candle goes with the balloon because they're for birthdays", and so on. These five year olds did not generally change groups once they had formed them, and most were rigid in their classification and unable to add to it once they had completed a group; thus there might be a number of groups called "metals". Many instances of singles sorting occurred with both blocks and arrays and the child tended to name each item. Many unexplained groups occurred.

Some eight year olds seemed to decide on a grouping strategy and to sort consistently towards it, but most eight year olds were still largely unable to alter groups once they were formed. Pairing and singles sorting with unexplained grouping still occurred, but these were less evident than in the five year old group.

The presence of a definite grouping strategy showed itself in the sorting of many ten year olds. The child, having briefly surveyed the objects, would start to classify them in a planful way. With attribute blocks the intention of the child was usually clear to the tester before he explained the groups. Some children would announce, "I'm going to sort these by size and thick/thin", and then proceeded to do so. The groups formed by ten year olds were generally larger with fewer objects in each, and the child was readily able to "about face", and alter groups to fit chosen criteria. Thus two groups of metal objects might appear at different stages in the sorting and later be coalesced. Grouping was now generally explained and logical, but some pairing was still present in the grouping of ten year olds. The placing of objects as singles had disappeared except for a very few "unexplained" responses at the conclusion of array sorting.

Both ten and twelve year olds were faster at completing the tests and most appeared to be operating on a grouping strategy, however the extent of this was difficult to determine in the case of arrays if children did not explain groups as they did them. In twelve year olds, singles groupings had disappeared (except for one instance) and only 2% of twelve year olds gave unexplained responses. (Tables VII and VIIIa.)

2. It is surprising that significant differences were not reported for <u>sex</u> and any of the dependent variables. One might have expected sex differences in inclusive discrimination (equivalence range) since these were reported in the research literature. The findings in the present study were however ambiguous. Sex differences in groupings and choice of criteria were not revealed either. Differences between boys and girls were sought in terms of logic and sorting behaviour, but again significant differences were not reported.

3. This study examined <u>criteria</u> used as a basis for grouping. Five year olds showed a preference for shape and colour, while twelve year olds preferred material as a single attribute for grouping. Shape remained an important criterial choice for all groups, with blocks, but for arrays it became less important. Use and material categories increased with eight, ten and twelve year olds. With increasing age, weight and texture became a criterial choice for arrays, and more sophisticated grouping criteria were used. Five and eight year olds tended simply to name items and many five year olds simply repeated a single criterion such as "big" or "round" for all their groups. Ten and twelve year olds used a wider selection in their choice of criteria with increasingly abstract categories (see grouping changes P. 64). Differences between groups were very highly significant (Table XIb).

It was hypothesized that five year olds would group objects more frequently on the basis of responses which could be classified as affective and perceptible (colour, size, shape etc.), and that eight, ten and twelve year olds would group more frequently by functional criteria. The hypothesis was supported with arrays since more five year olds gave perceptible responses and there was a decrease in perceptible responses from eight, ten and twelve year olds (Table VIIIa and Table XIII P.41 and 47). Very highly significant differences were recorded between groups (Table VIIIb). The hypothesis is supported for functional criteria, with an increase in the functionally based use category in eight, ten and twelve year olds. These results show a definite shift from concentration on surface perceptible properties ("red", "round", "long"), chosen by five and eight year olds to the more embracing functionally based categories ("modes of transport", "valuable", "man-made"), used by ten and twelve year olds, which lends support to Bruner's contention that more efficient grouping is now possible. (See grouping changes P. 64)

4. It was observed that different criteria were used to group different stimulus material. Thus while there was some overlap in criteria, children tended to use criteria such as size, shape or colour for attribute blocks, and criteria such as use or material formed the basis for separating array materials. These differences emerged both when the same child's sorting was compared, and also when groups of children were examined for differences in sorting the stimulus and array materials. This data provides support for the hypothesis suggesting differences in criterial groupings in stimulus materials. The different stimulus materials provided the basis for a variety of different observations throughout the study. Array materials were better than attribute blocks in producing examples of unexplained groupings and for showing increasing abstraction in grouping criteria, and they provided a greater variety of sorting. Attribute blocks were better for showing spatial configurations, contiguity and patterning.

The potency of stimulus material is seen as affecting pattern making (Table XIX P. 55). Five year olds produced thirty-seven geometric pictorial and fantasy arrangements with attribute blocks, and ten with arrays, eight year olds twenty-six and two, ten year olds two and two and twelve year olds seven and two. Seventy-two instances of such arrangements occurred with attribute blocks, as compared with sixteen with array materials.

5. The kinds of grouping produced were of interest. 26% of five year olds produced groups as singles arrangements, placed groups in unexplained piles, or produced fantasy arrangements.

Only 2½% of eight year olds sorted materials in these ways, and with older children the phenomenon tended to disappear. A common form of grouping observed in five year olds was a "pairing" response where the child places an object and then matches a second similar object beside it to form a group i.e. Two thick triangles, two animals, both round, both steel and so on. Pairing appeared in the sorting of 31% of five year olds, 9% of ten and 4% of twelve year olds. "True" grouping by explained logical criteria was found in 42% of five year olds, 79% of eight year olds, 90% of ten year olds and 95% of twelve year olds. These results were highly significant (<0.001).

Five year olds tend to form more groups with fewer objects in each, while eight, ten and twelve year olds tended to form increasingly fewer groups, each with more objects. Typical grouping might appear as follows:

GROUPING CHANGES

AGE	OBJECTS	EXPLANATION
5 year olds	crocodile, kangaroo	"Kangaroo" and "crocodile" or "'Cos they're animals".
8 year olds	crocodile, kangaroo	"Both - alive - animals".
10 year olds	crocodile, kangaroo, man	"All living things".
12 year olds	crocodile, kangaroo, man, bus, boat, bike	"All can move".

Five year olds tended simply to name items. With increasing age more abstract categories were used. Superordinate grouping appeared in the classification of twelve year olds, supporting Vygotsky's thesis in this. As Bruner et al (1966) suggest, there is a shift from concentration on surface perceptible attributes to the more embracing functional properties with increasingly comprehensive grouping until finally inclusive classes are formed which require the ability to abstract superordinate concepts. Increasingly efficient grouping strategies appear with less rigidity in sorting behaviour.

6. Pattern making appears to be linked with grouping and sorting behaviour in younger children. Pattern making appeared as geometric, pictorial or fantasy arrangements which are produced by 29% of five year olds, 18% of eight year olds, 2.5% of ten and 5.6% of twelve year olds. Linear arrangements of groups is related to pattern making and linearity appears in some children of all age groups. Stimulus materials appear to have influenced pattern making strongly since it appears much more frequently with attribute block arrangements.

7. Inclusive discrimination was presently described as the observed tendency to form few or many groups on these sorting tests. Wallach & Kogan (1965) suggest that the related equivalence range and category width dimensions may be linked with cognitive style and may show significant sex differences. It was thought that the present test for inclusive discriminators might show possible relationships with wide categorizers, and that more boys than girls might show inclusive discrimination by forming few groups with the stimulus material. Computer analysis showed no significant differences between the sexes in forming few or many groups, and it is the only dependent variable scanned which showed no significance with age. Of the 320 children tested 62 demonstrated inclusive discrimination. (Tables Xa and Xb). Ten of these children showed inclusive discrimination for both blocks and arrays, seven males and three females. (Table Xc.) This more stringent test constraint

seems to indicate more boys than girls as inclusive discriminators. The numbers of male and female inclusive discriminators identified here are too small to permit generalizations from them, the trend however, should be noted. Possible links with personality variables have been suggested for category width. Personality factors may also apply to the inclusive-specific discrimination dimension. The relationship was not established with independent variables in the present study, but the numbers of inclusive discriminators identified were few, and the independent variables did not discriminate personality in this instance. Further investigations might seek possible links between sex, personality and perceptual factors which may influence inclusive discrimination.

8. Language responses were recorded during the study. Inhelder & Piaget (1964) have pointed out that the child's use of such phrases as "Dogs are animals", or "Some of these are red", may be grossly misleading as a guide to his classifying. Lovell (1955) Bruner et al (1966), Nixon (1971), and many others have suggested that class concepts are less dependent on verbalization in their formation than are some other concepts. The child's early classificatory behaviour would seem to be strongly based on perception and action upon materials may indeed be more crucial in the development of classification concepts than language. Language at this stage is a necessary but not sufficient condition for developing classificatory skills. It was evident from observations of children's block sorting that some children could group consistently according to logical criteria and yet be unable to explain what they had done. This finding agrees with that of Mary Nixon (1971). Nevertheless it is considered that a child's ability or inability to explain what he has done may provide some clues to his grouping behaviour. The results showed 39% of unexplained groupings for five year olds as opposed to 15% for eight year olds, and 7% for ten year olds with 2% of unexplained groups for twelve year olds. Highly significant results were obtained for comparisons between each age group and the numbers of unexplained grouping results. (Table VIIIb).

No significance was shown between the sexes. These results indicate that age rather than sex is operating in children's ability to explain and describe their groups. Perceptible and functional categories have already been discussed under grouping criteria. Language responses were recorded but not quantified in the present study, but it was clear that trends followed those described by Olver in Bruner et al (1966) for syntactical and semantic groupings. Complexive language was associated with perceptible attributes. Complexive thinking was most obvious in those five and eight year olds who formed a large number of singles groups with arrays. Having agreed that each group was discrete, the child would often link each object into a complexive language statement, i.e. "The bead is round and so is the wheel and this top has a round end ...", and so on. Thematic statements were rare but they occurred occasionally associated with fantasy and building arrangements. "... The animals are in a paddock and that over there is the dairy so they can get something to eat". (See Figure 16b, top photograph.) Superordinate language groups were also found to be linked with functional criteria in the present study, thus "wheel objects" for bike and bus and wheel, or "valuable" for the ring, scissors and penny, and so on.

It seems most likely that language plays a key part in the higher classificatory operations of hierarchical ordering. This investigation did not seek to establish the presence of formal operational thinking in those twelve year olds tested. Piaget points to the attainment of true logical thinking at early adolescence from eleven years onwards. Vygotsky on the other hand, suggests the gradual attainment of adult logical thinking (which he calls concept formation) during adolescence. Vygotsky writes, "... the adolescent will form and use a concept quite correctly in a concrete situation, but will find it strangely difficult to express that concept in words, and the verbal definition will, in most cases, be much narrower than might have been expected from the way he used the concept". Vygotsky (1962) P. 79. In the present study a wide variety of language was recorded from twelve year olds - some showing complexes, but mostly providing examples of functional superordinate language structure. Language development showed a gradual tendency to abstraction in describing more logical groups.

9. The present study investigates the ability of children to sustain logical grouping, and seeks support for the underlying assumption that chronological age provides some measure of maturity and experience in the children studied. Chronological age is a quantitative descriptive control variable unable to account for variations within age groups. A sample size of eighty in each group should here provide sufficient data for reporting age related trends.

It was hypothesized that five year olds would typically tend to form groups which lack logical criteria as their basis. The data showed that 29% of five year olds showed shifting logic in their grouping, as opposed to 7½% of eight year olds and 4% of ten and 2½% of twelve year olds.

The grouping of five year olds ranged from syncretic heaps and singles arrangements through pairing with partial logic and grouping with shifting logic to pairing with logical criteria, to totally logical groupings with somewhat fewer groups formed. Eight year olds were less prone to shifting logic in their grouping and less pairing occurred. In ten year old subjects illogical sorting occurred in only two instances of 160 tests. Placing objects singly had disappeared except for a few "unexplained responses" at the conclusion of array sorting. Fantasy and figural arrangements did not occur in the sorting of ten year olds who were firmly anchored in the concrete and factual world of grouping. Attribute blocks were sorted by logical criteria and consistently logical grouping performed. Twelve year olds produced no singles arrangements and their sorting was logical with more objects per group for arrays. Pairing had almost disappeared (2%) but some three instances of fantasy arrangements and fourteen of unexplained groupings occurred. In general the children showed a progression from grouping by a single attribute, to the use of several attributes and the formation of inclusive class grouping.

Inhelder & Piaget (1964) describe three rough stages in the development of classificatory operations. The child's first grouping ($2\frac{1}{2}$ - 5 years), produces graphic collections which result from a planless step by step process in which sorting criteria are constantly shifting. Some grouping may be formed on similarity of attribute but the arrangements are fragile and unstable, and the classes are not sustained. The child cannot differentiate and hence cannot coordinate class comprehension. The preoperational child can "see" similarities but cannot distinguish logical from infralogical operations at this stage. (Flavell (1963)).

Some sorting of five year olds resembled the figural collection sorting described by Piaget (Figures 19a, 19b, 20, 21, 22 and Figures 16a and 16b). Most of these sortings more closely resemble the "chain complexes" described by Vygotsky, "Which form a dynamic consecutive joining of individual links into a single chain with meaning carried over from one link to the next". P. 64. The child is perceptually tied and becomes distracted by the appearance of his objects (Bruner's Ikonic Representation also describes this phase). Criteria are constantly shifting and a single trait is not extracted from the next by the child at this stage. A very few conglomerate heaps appeared in the sorting of five year olds which were not explained, and which resembled Vygotsky's earliest grouping form the syncretic heap (Figure 22).

Piaget describes graphic collections as giving way to non-graphic collections somewhere between five and a half and seven or eight years*. The child forms groups on the basis of similarity of attribute and may form subordinate groups, but he still cannot grasp the class

*Footnote

Some of the figural arrangements and patterns produced by the five year old children might be described by Piaget as "graphic collections".

inclusion relation which is basic to true classification. The operational structures necessary to solve problems of hierarchical classification do not develop much before twelve.

In the present study grouping showed a similar progression in the developmental sequence, but the observations were not related directly to the Piagetian model. Some exceptional children appeared able to perform class inclusion tasks earlier than would be expected, but further testing would be necessary to ascertain that this was so.

The pairing response referred to in this investigation is implied (but not described) in the work of Piaget & Bruner but is not fully described by either. In the present study pairing occurs as equivalence sorting with matching similar objects "two toys", "two bricks", "two circles", and it occurs as grouping by contrast "a fat and a skinny one go together". It also appears as one to one correspondence, "The hat (toothpaste top) goes on the man", "The flag goes on the boat", "The peg goes with the cloth", and so on. Criteria for pairing uses both perceptible and functional attributes. This kind of grouping was obviously age-related (Table Va) being common amongst five year olds but still present in the grouping of some ten year olds. This pairing response was so marked in the sorting observed in the present study that it would appear to warrant further investigation. Does pairing occur in the sorting of two - four year olds? What perceptual factors are operating in pairing? Is such grouping affected by test instructions? Is pairing a universal phenomenon in the grouping of young children or is it perhaps affected by the educational curriculum?

10. Children's classificatory behaviour is demonstrated by an increasing complexity of groups formed. Individual differences assert themselves in terms of the numbers of groups formed and the types of arrangements produced. Contributory factors were

sought in terms of sex, number and position in the family, parent occupation, and educational background of the child. None of these variables showed as significant with any of the dependent variables. (Table IX.) It is suggested that the variables may require measures of a different nature. The present investigation observes simple sorting in grouping behaviour, and it does not discriminate between any of the independent variables except for age, where developmental sequences are demonstrated as differences in numbers of groups formed, criteria used, and logic in sorting behaviour.

11. Educational background was analysed in terms of parent occupation, school and pre-school attendance. The schools in this study were chosen as being similar and representative of the New Zealand population. It may be seen from Table IV P. 29 that the three primary schools draw from a similar range of occupations, and that the Intermediate School had a higher proportion of professional parents. While the schools appeared to be providing similar educational experiences for their pupils, the infant department at Awapuni School was using Invicta Attribute Blocks and involving pupils in classificatory exercises as part of the mathematics programme. It was thought that this might contribute to differences in sorting behaviour in terms of five year old school populations. No such differences occurred.

Descriptive and inferential studies of this kind inevitably raise further questions about such determinants as socio-economic class and personality which were not examined for their systematic effects, since one is not able to take account of all possible variables.

While age-related trends are reported, it is recognised that the samples are discrete and cross-sectional, and for stronger conclusions to be drawn, a longitudinal study would be desirable. In some instances, inferences are drawn on the basis of quite small numbers. The small numbers in some cells limits the generalizations which may be drawn from them. Nevertheless the consistency of the trends noticed with the populations studied adds to the confidence of the results reported.

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COLOUR ALONE

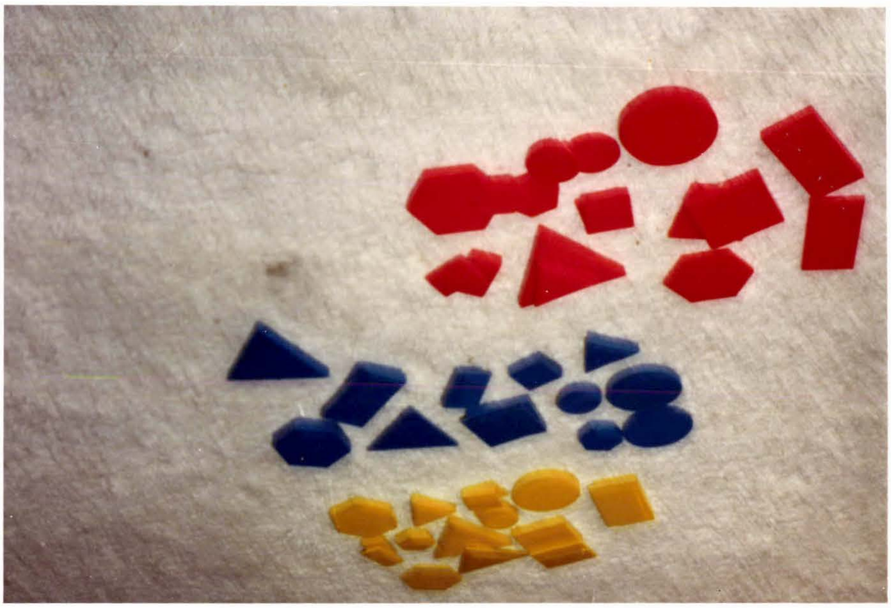
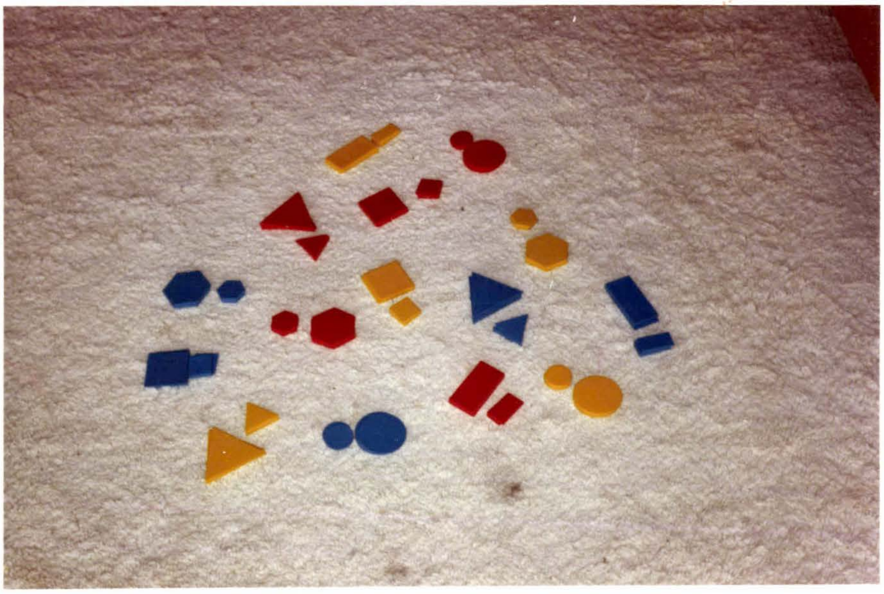


figure 1

COLOUR, SHAPE, THICK-THIN



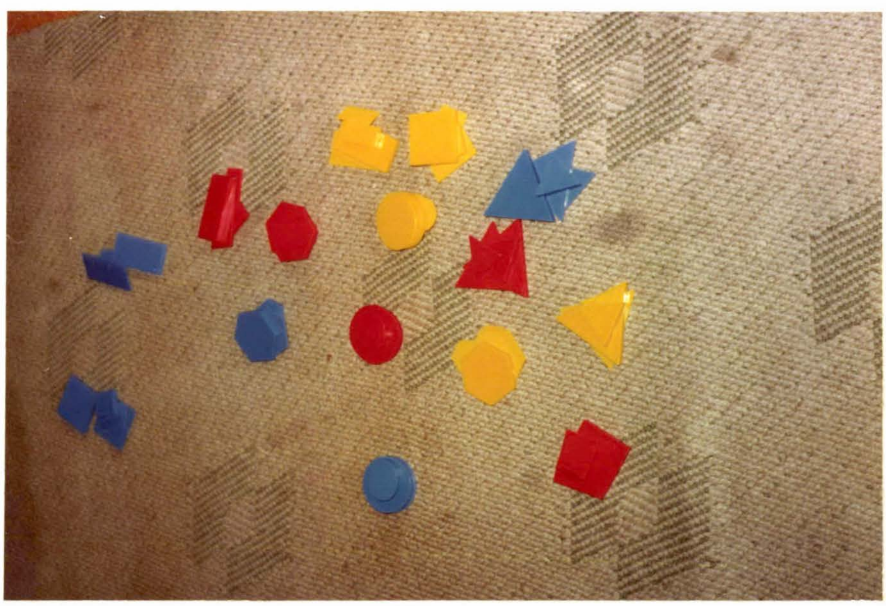
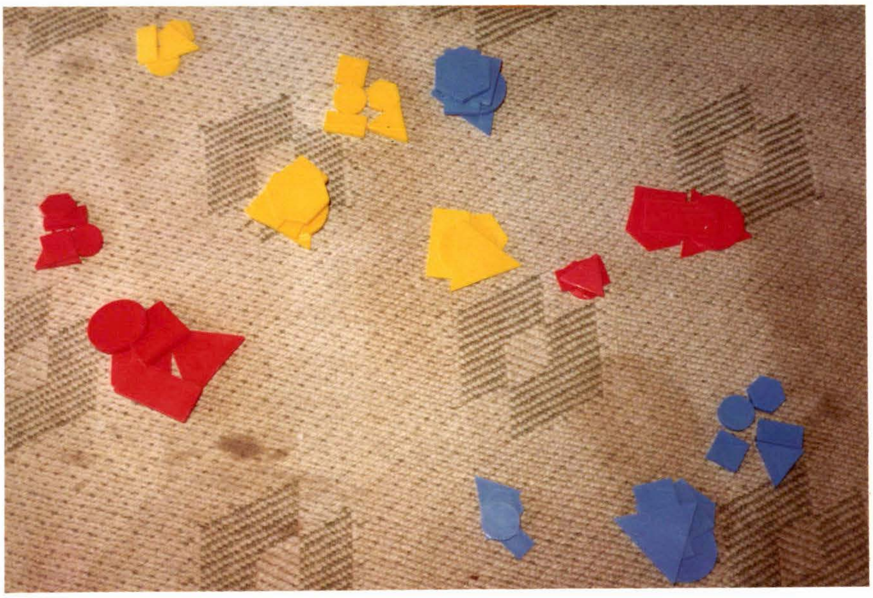


figure 2

COLOUR, SIZE, THICK-THIN



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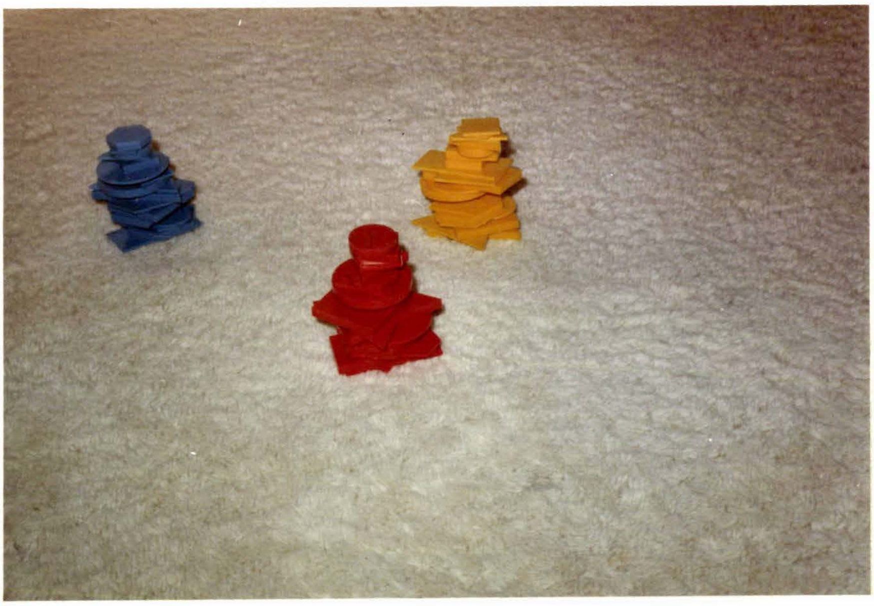
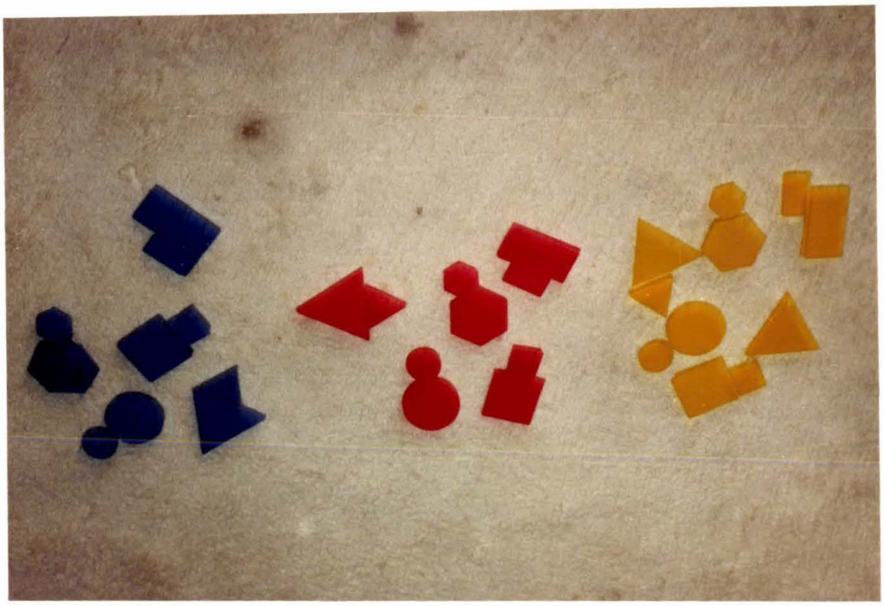


figure 3

COLOUR, THICK-THIN



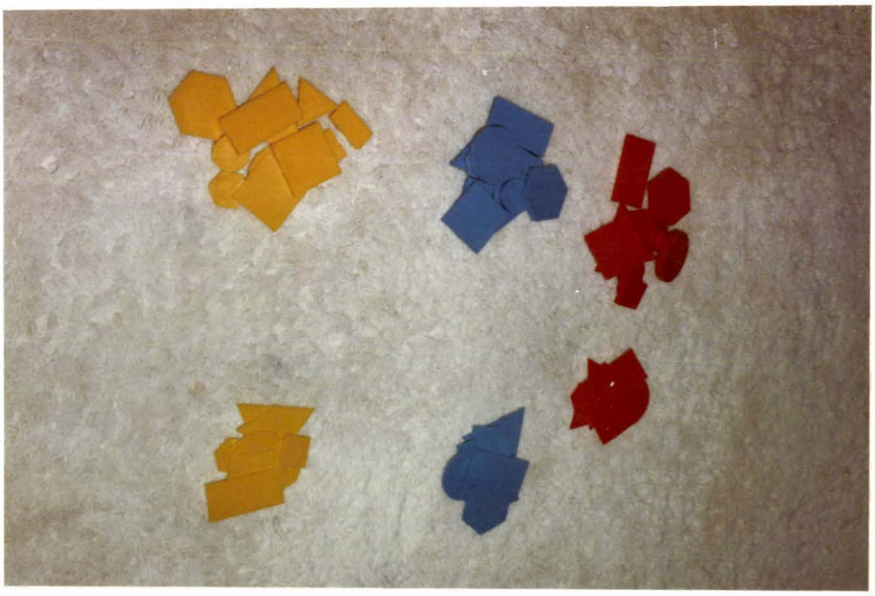


figure 4

ALL ATTRIBUTES
COLOUR, SHAPE, SIZE, THICK-THIN

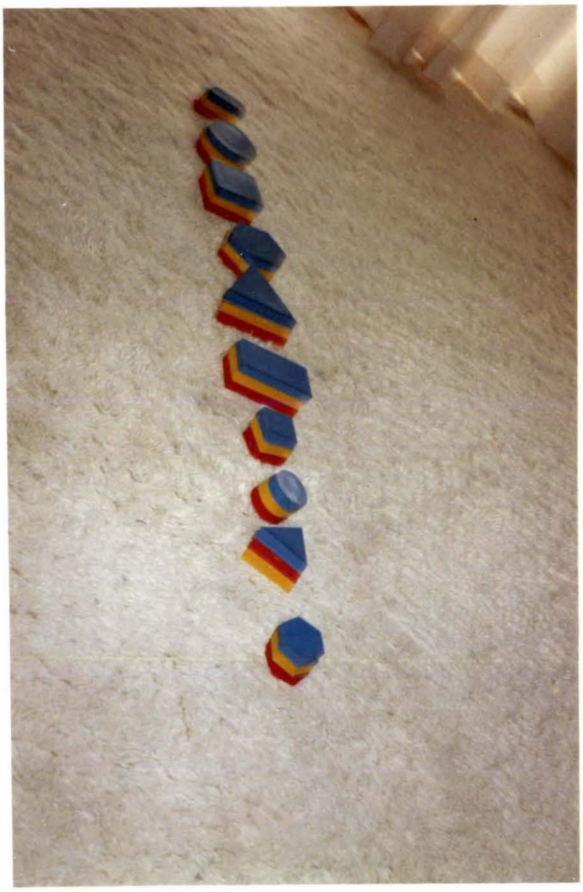
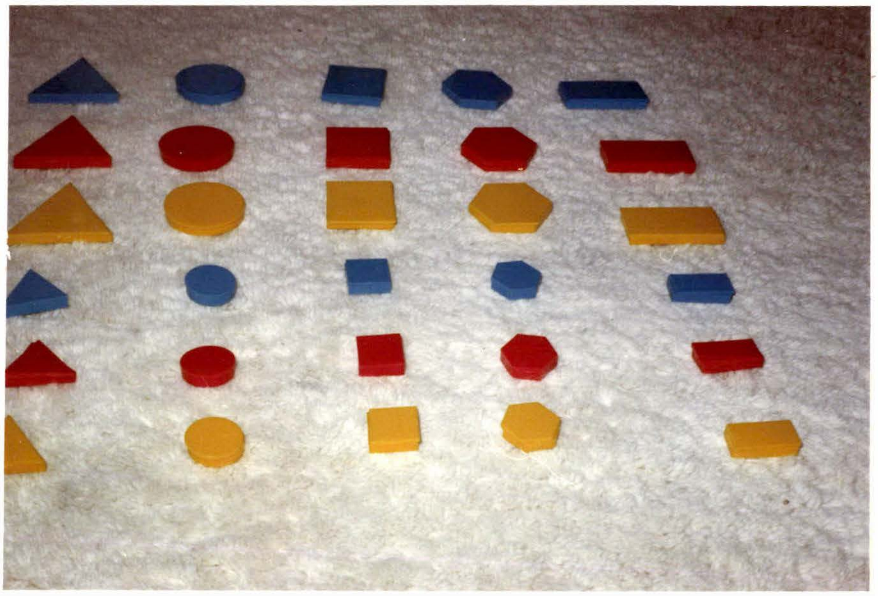


figure 5

ALL ATTRIBUTES
COLOUR, SHAPE, SIZE, THICK-THIN



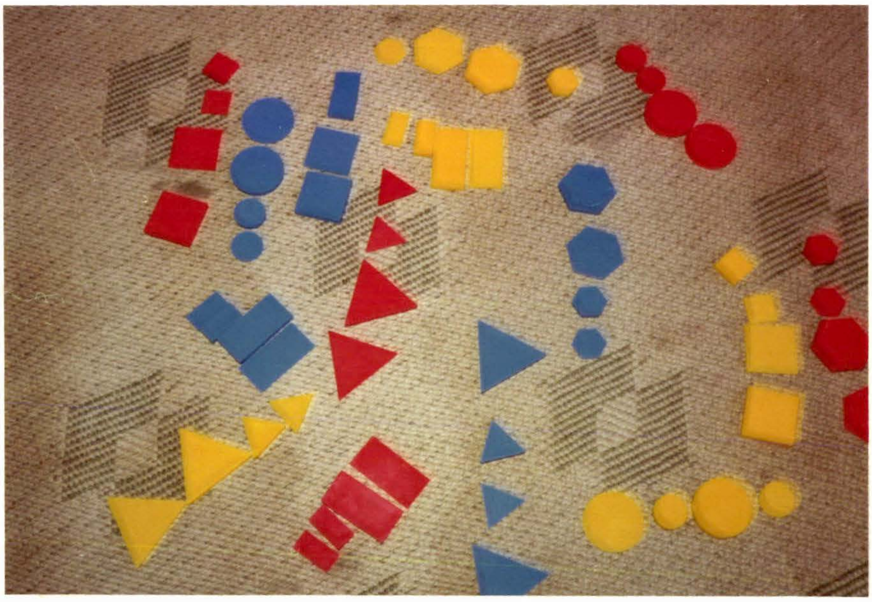
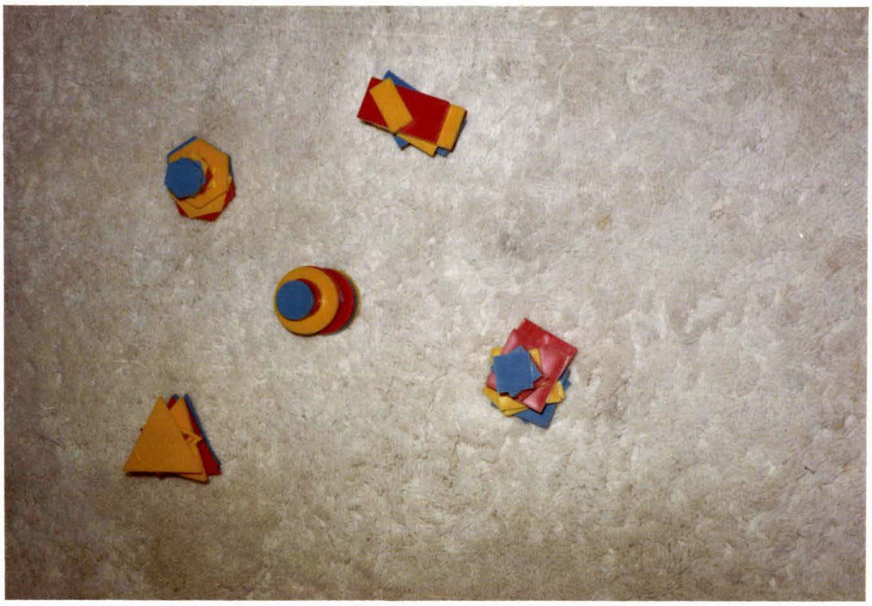


figure 6

SHAPE ALONE



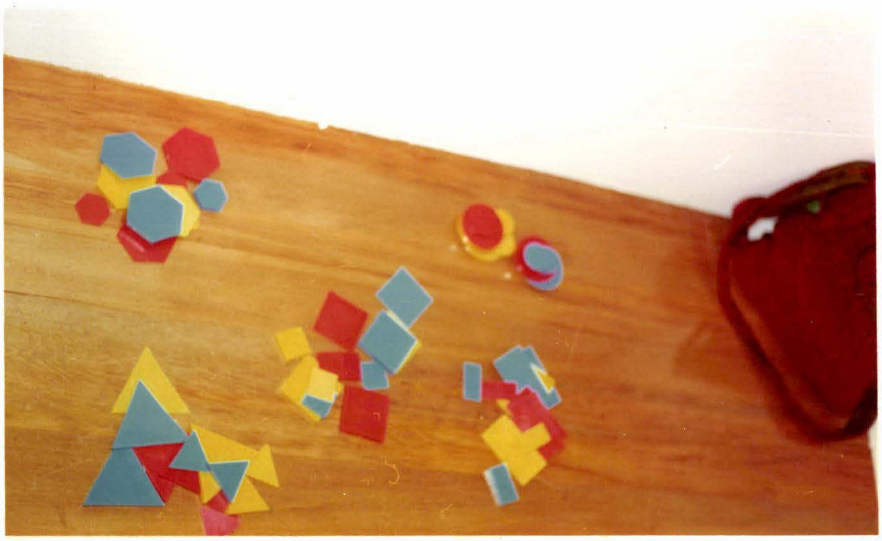
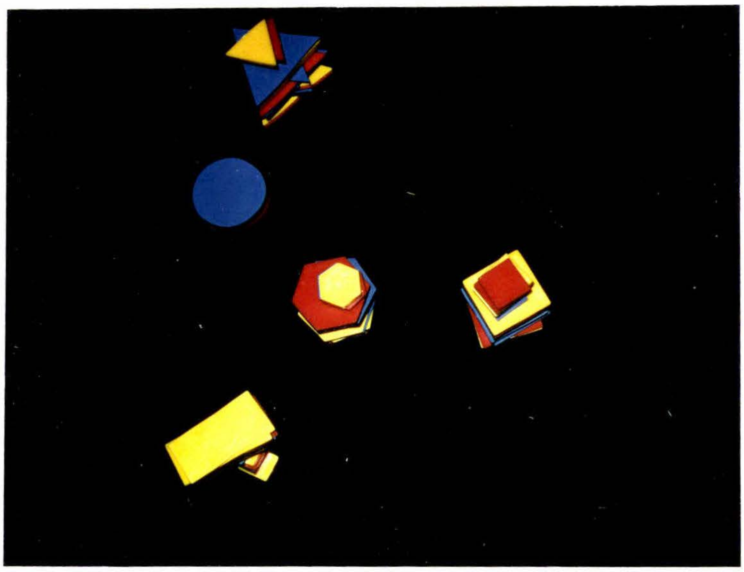


figure 7a

SHAPE ALONE



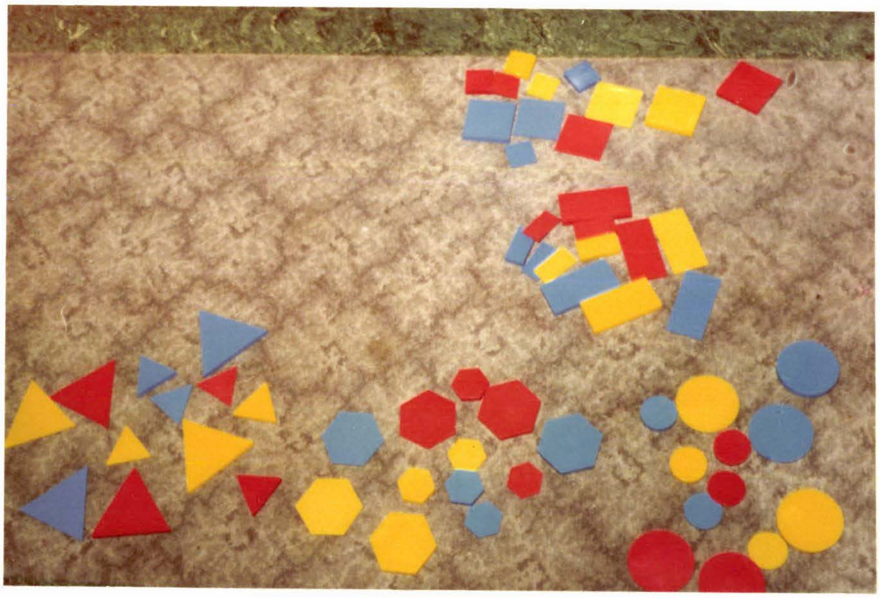
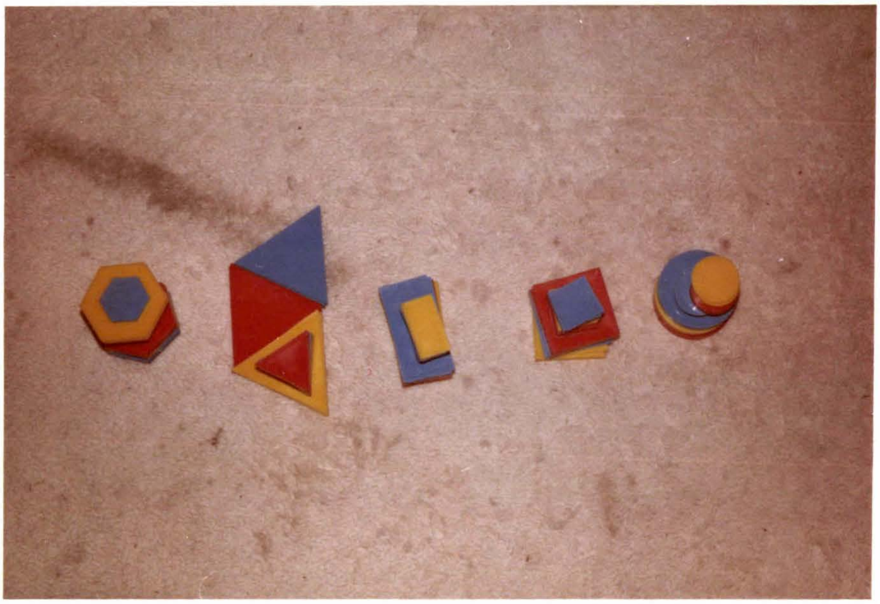


figure 7b

SHAPE AND SIZE



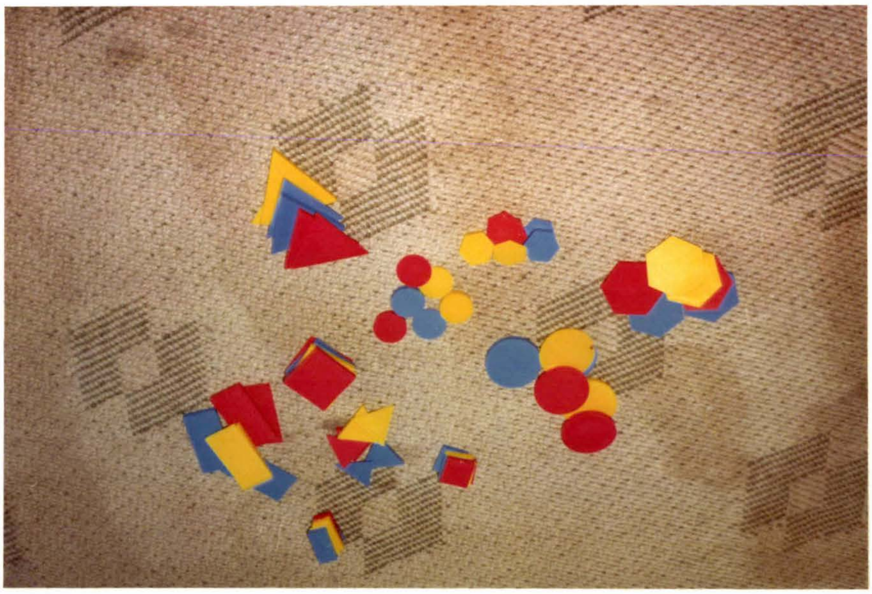
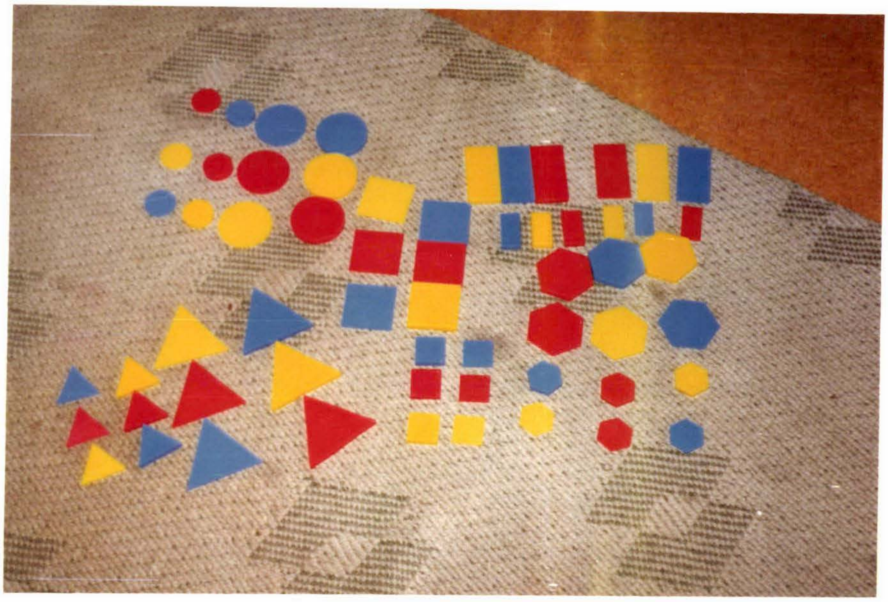


figure 9

SHAPE AND SIZE, THICK-THIN

figure 10a

SHAPE AND SIZE, THICK-THIN



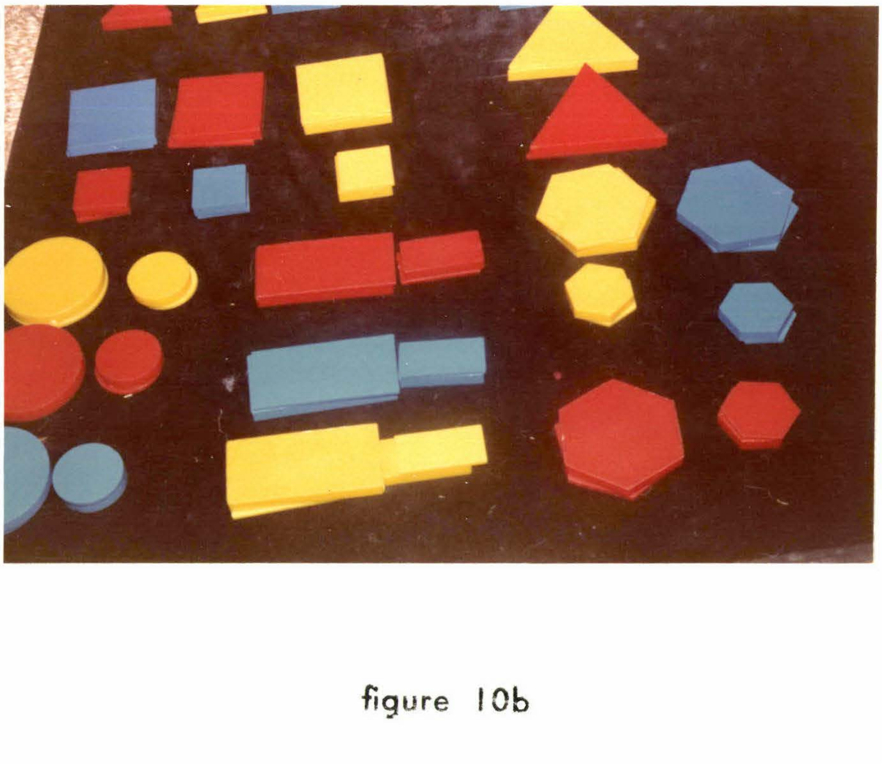
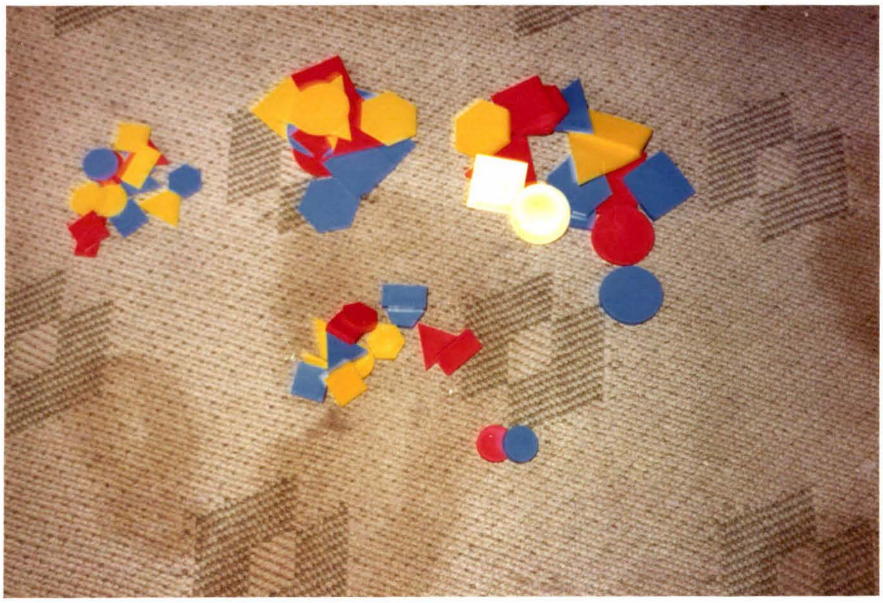


figure 10b

SIZE ALONE



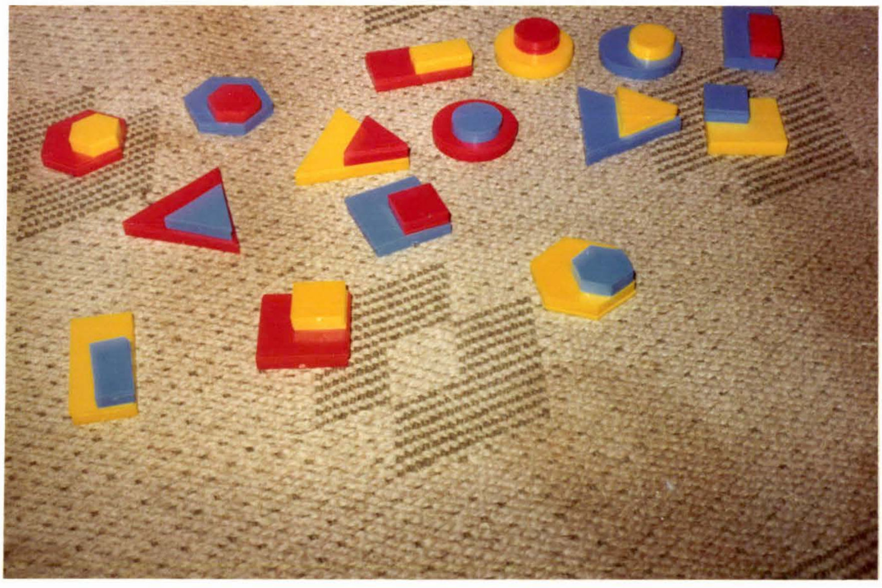
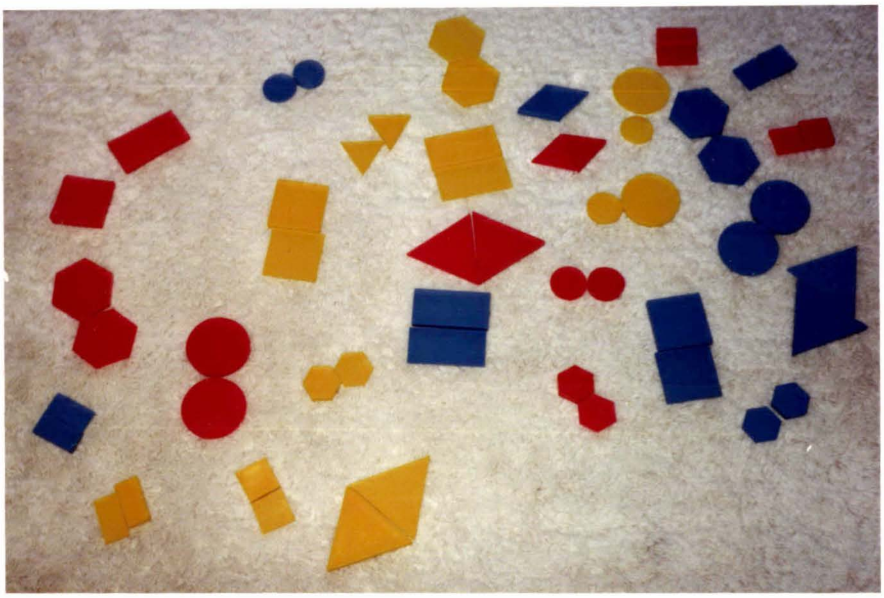


figure 11

THICK-THIN ALONE



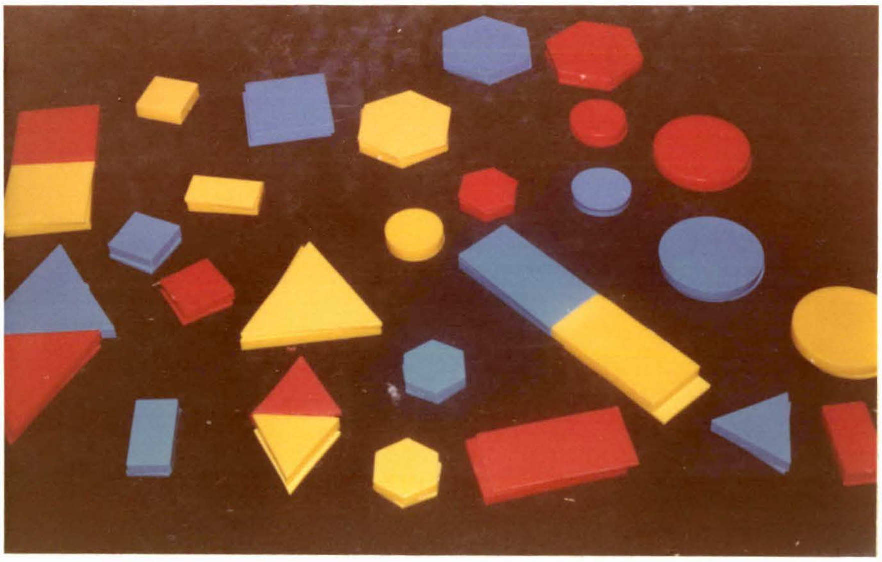


figure 12

PAIRING

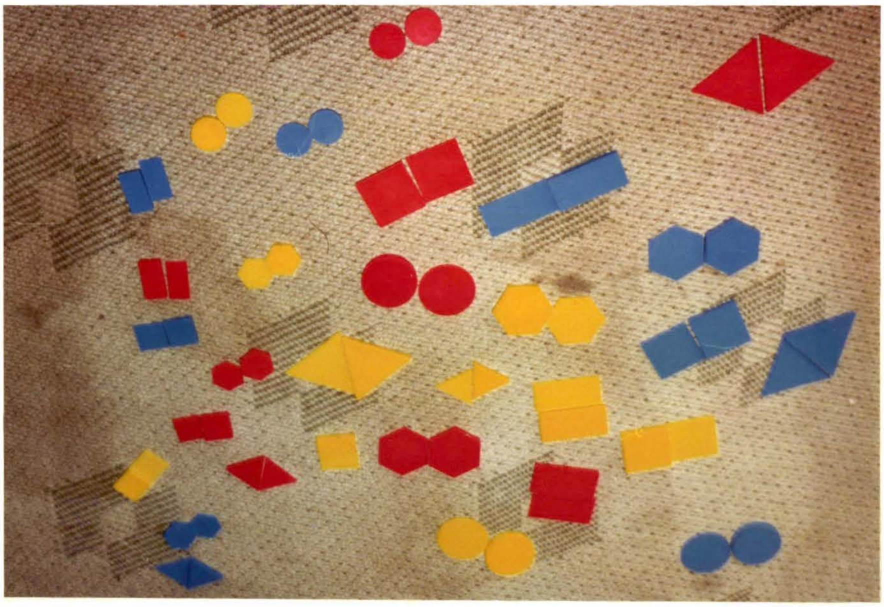
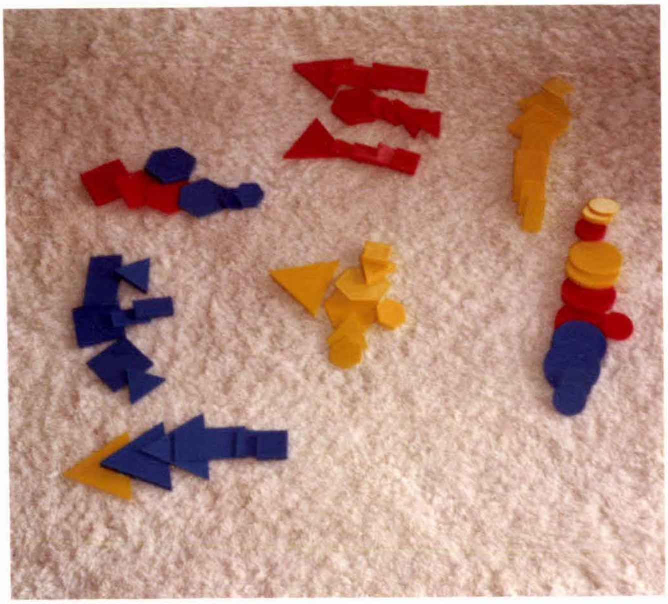


figure 13



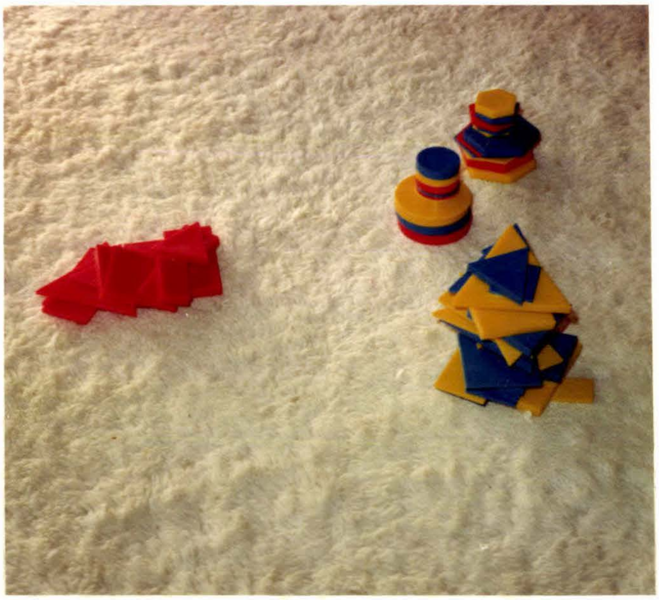
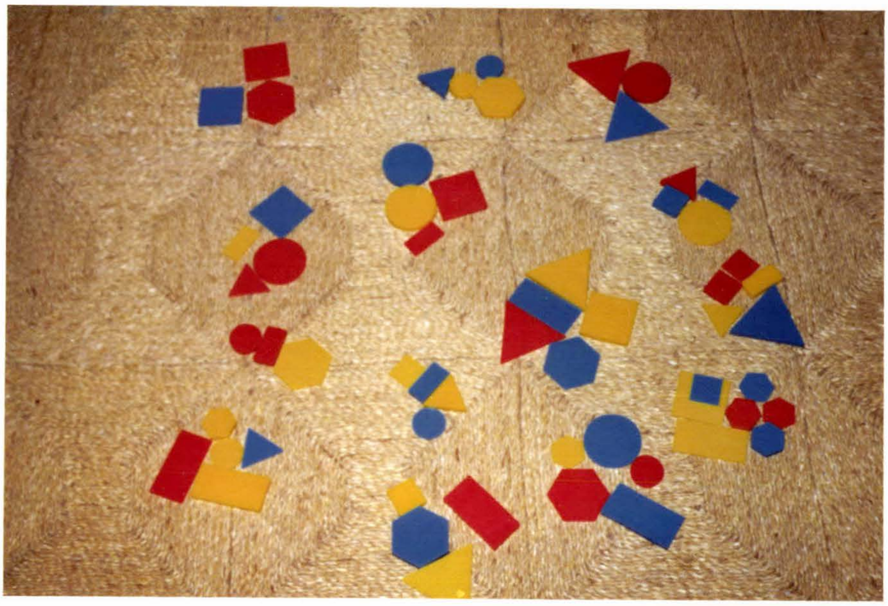


figure 14a



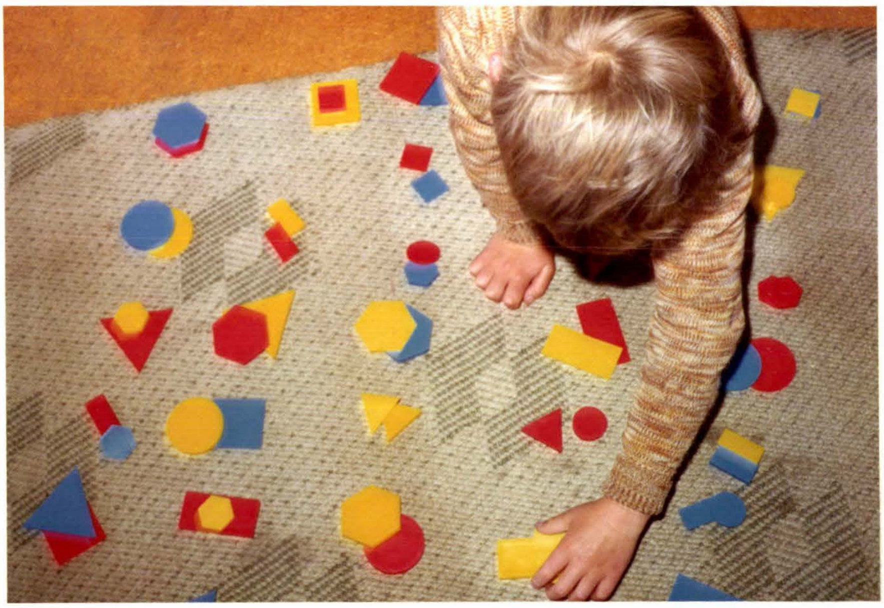


figure 14b

COMPLETE LOGIC

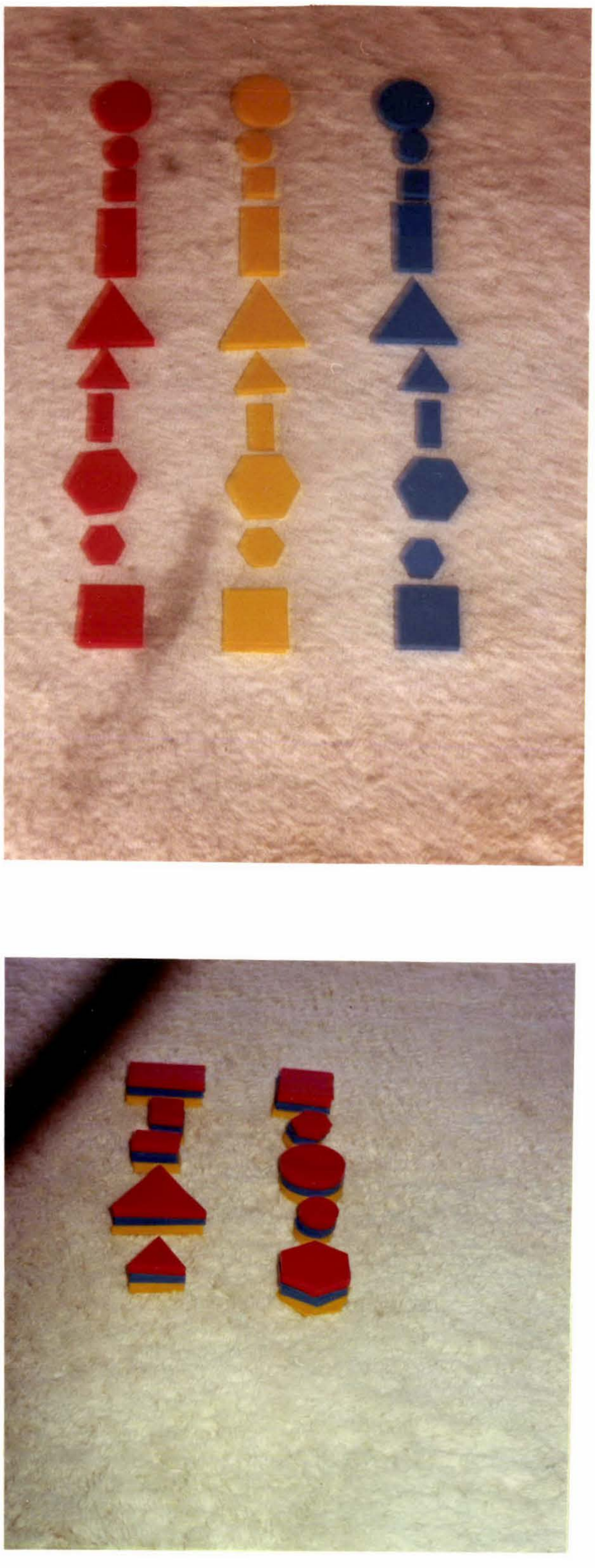
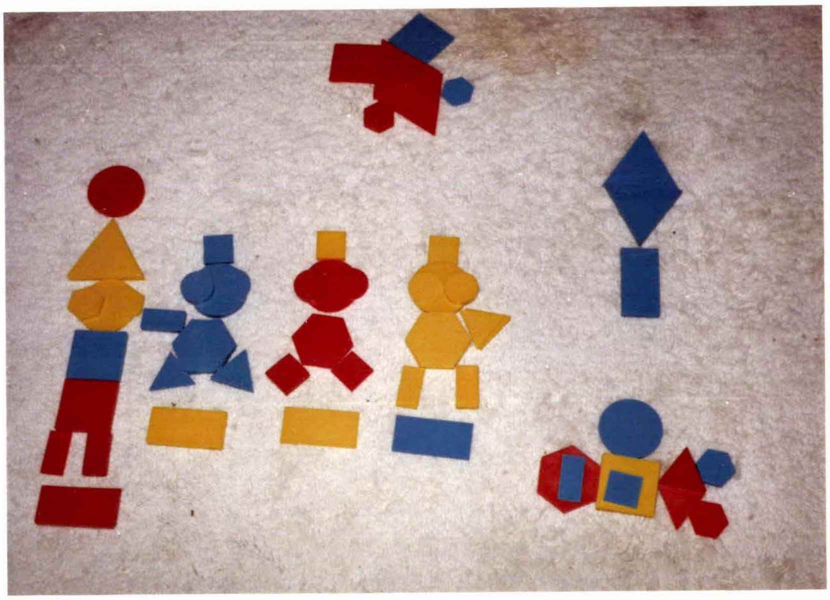


figure 15a

figure 15b

FANTASY



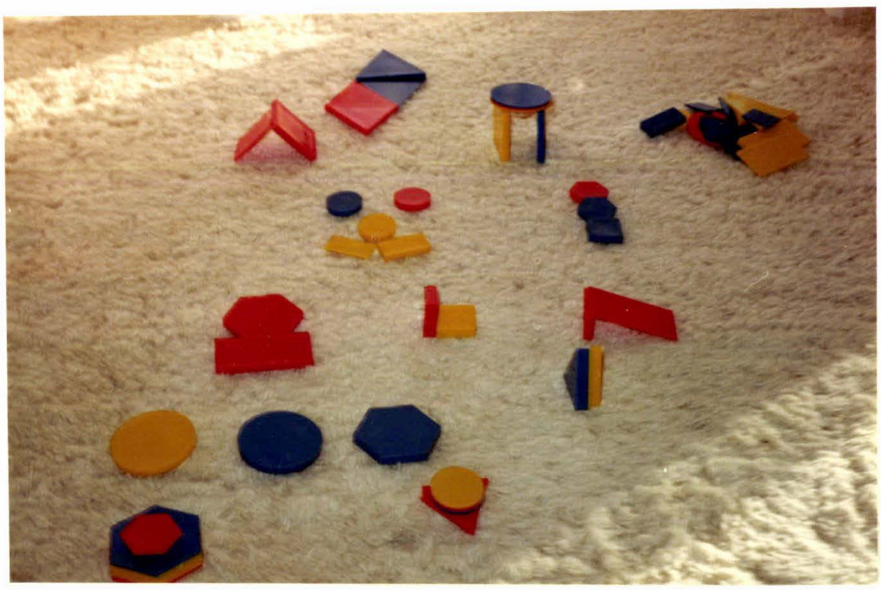
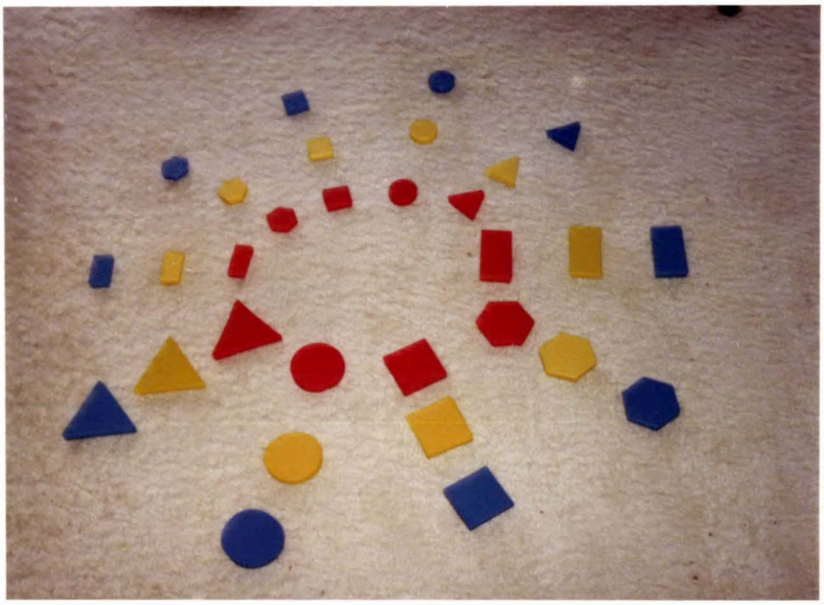


figure 16a

FANTASY

figure 16b



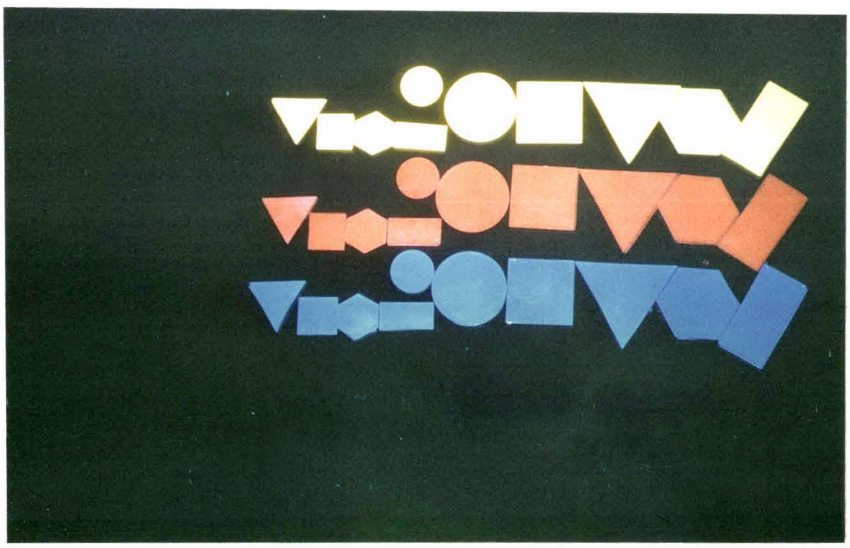
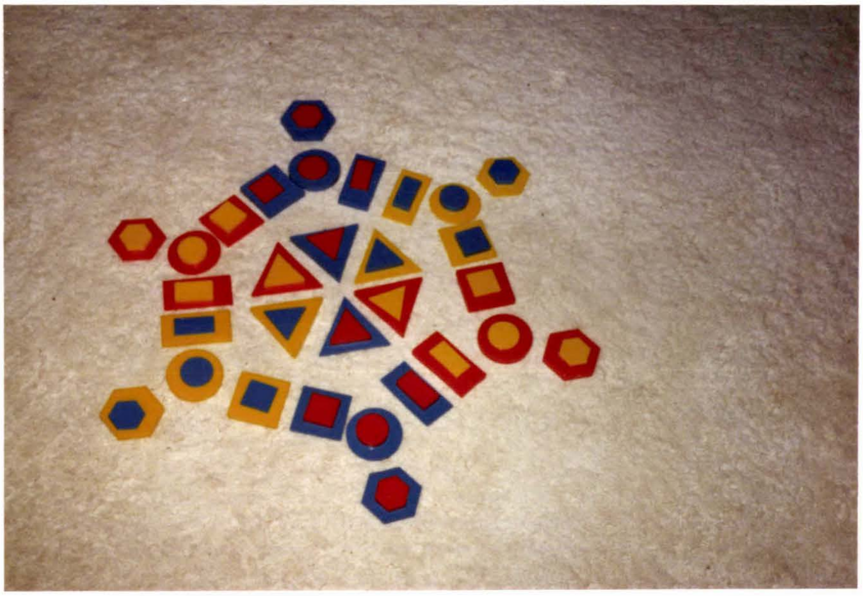


figure 17a



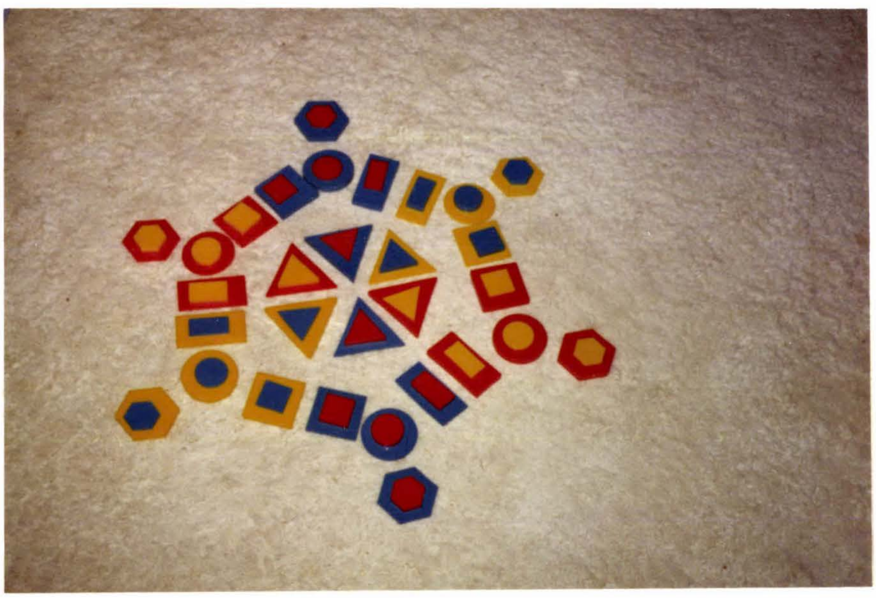
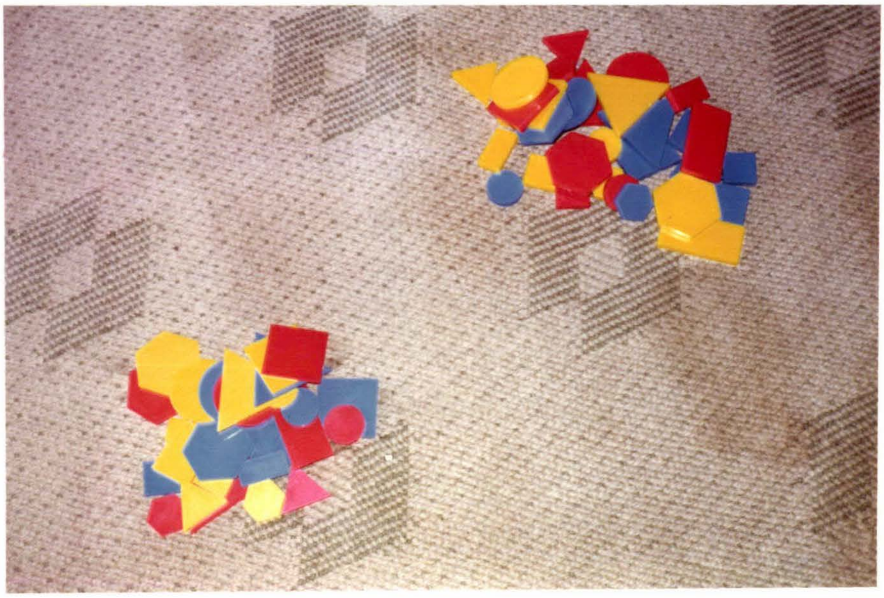


figure 17b

INCLUSIVE DISCRIMINATION



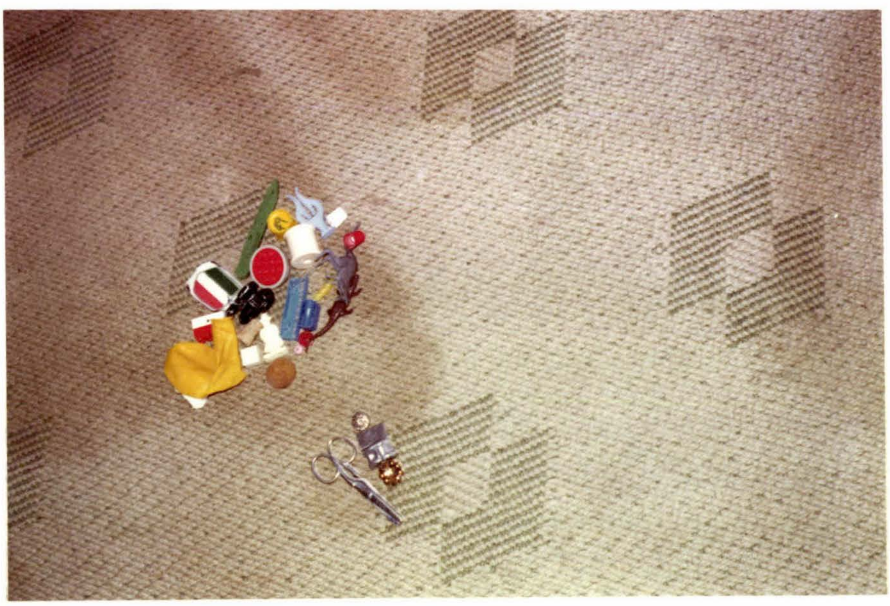
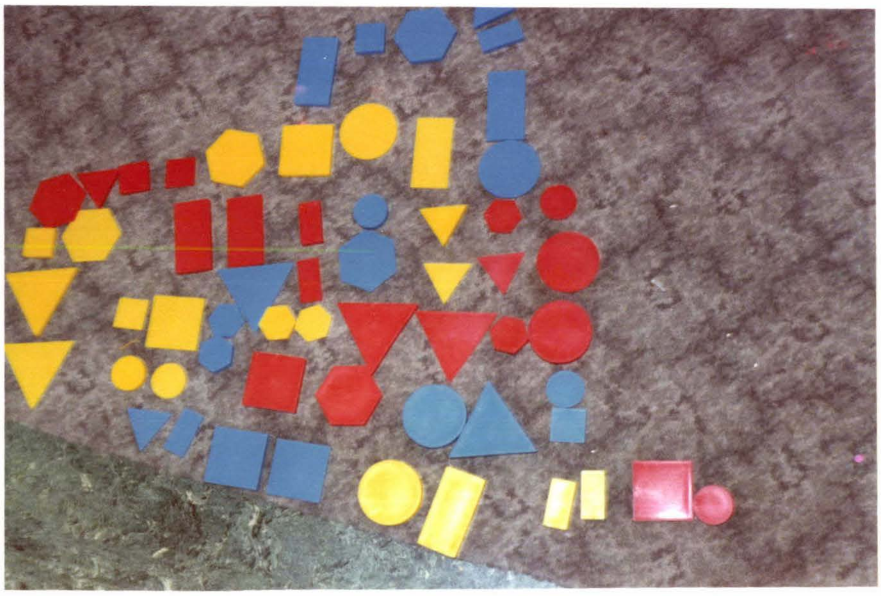


figure 18

CHAINING SINGLES



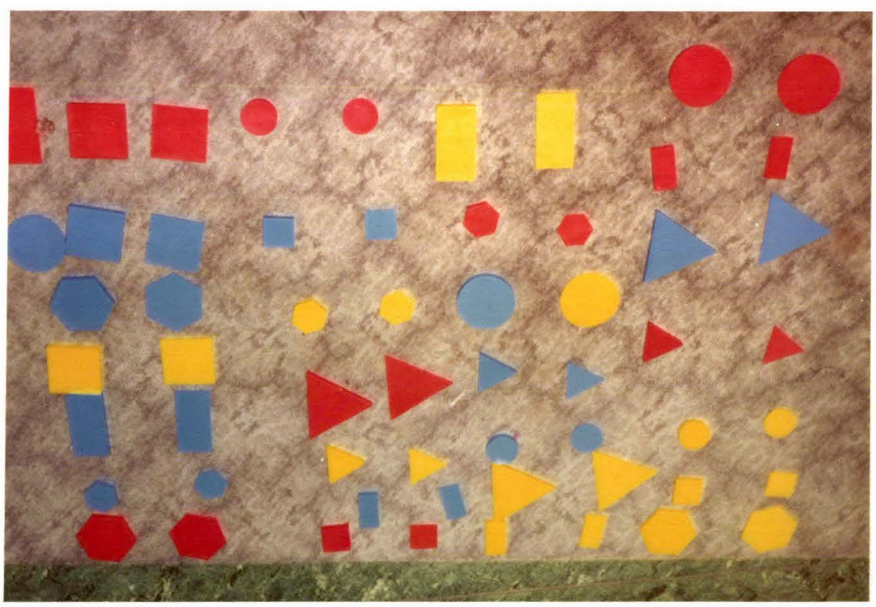
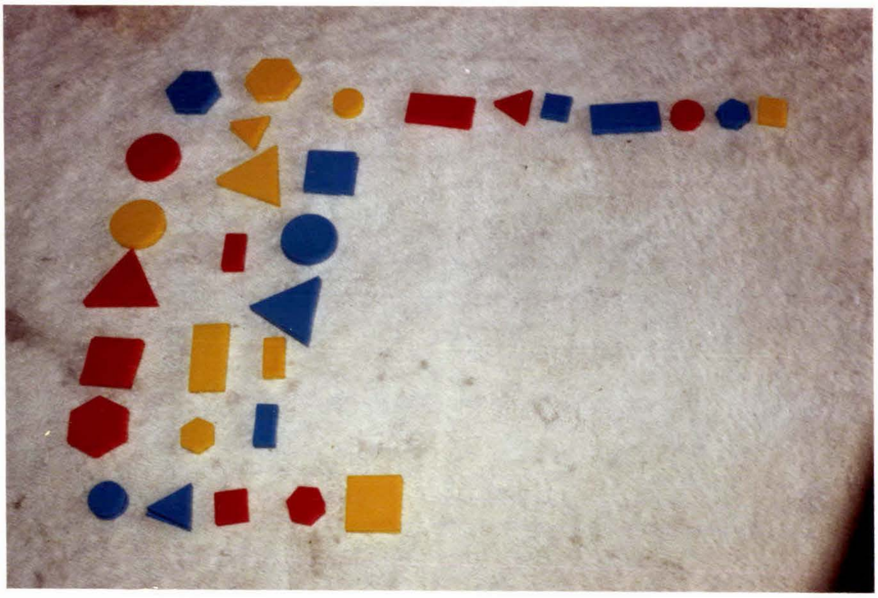


figure 19a

CHAINING SINGLES — LINEAR



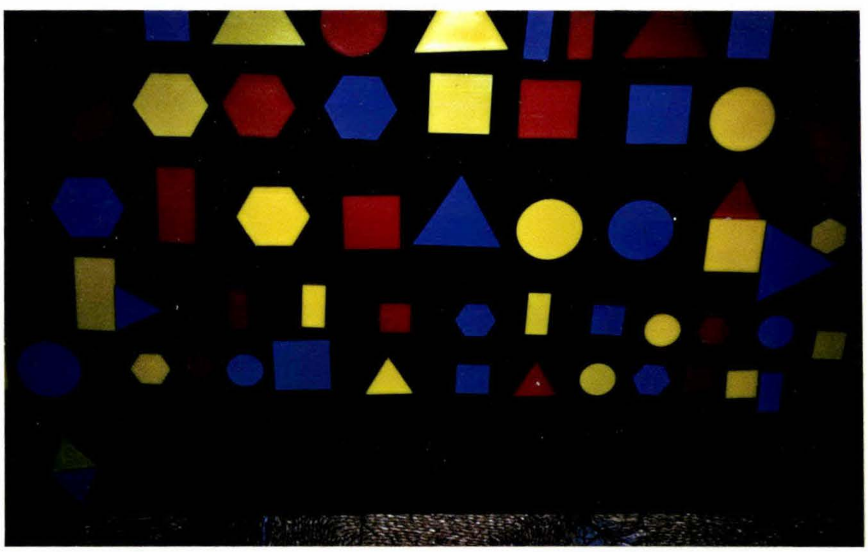
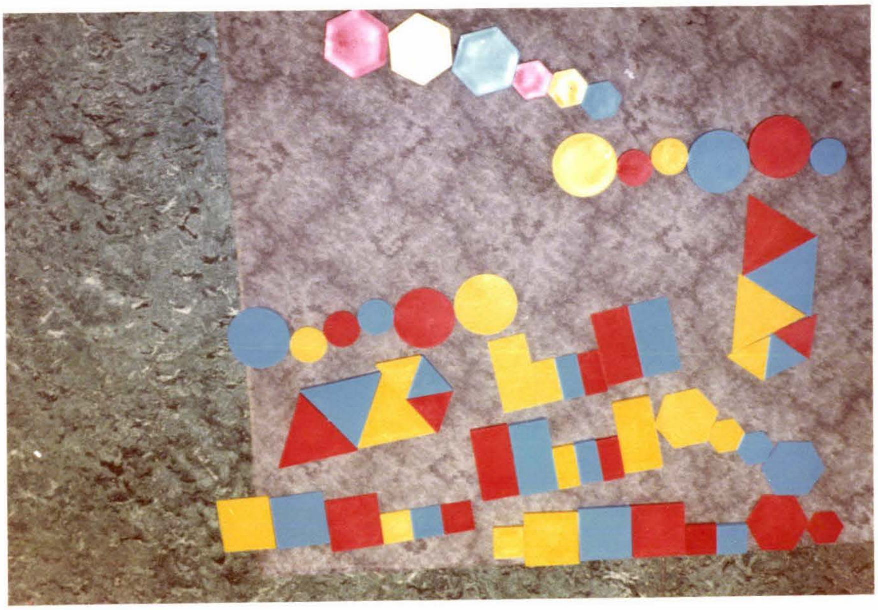


figure 19b

COMPLEX CHAINING



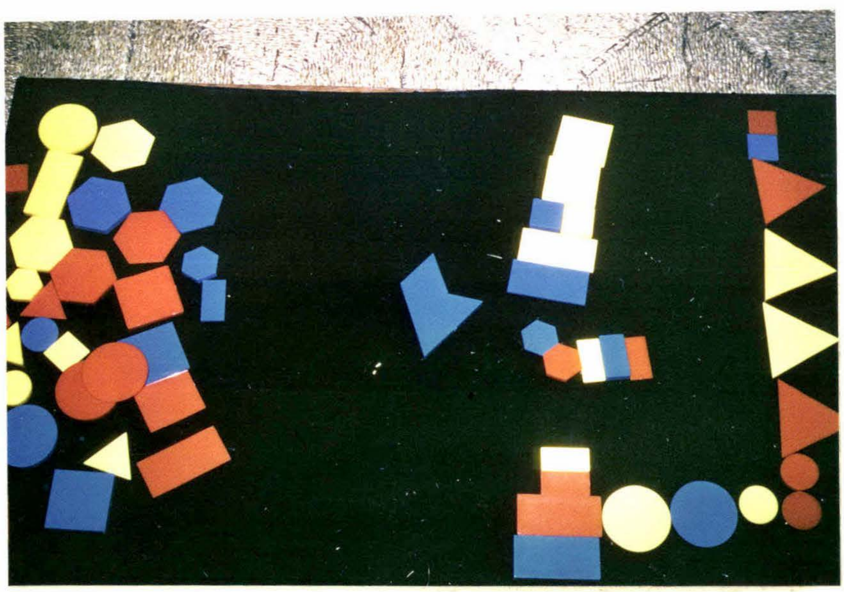


figure 20

COMPLEX CHAINING — GRAPHIC

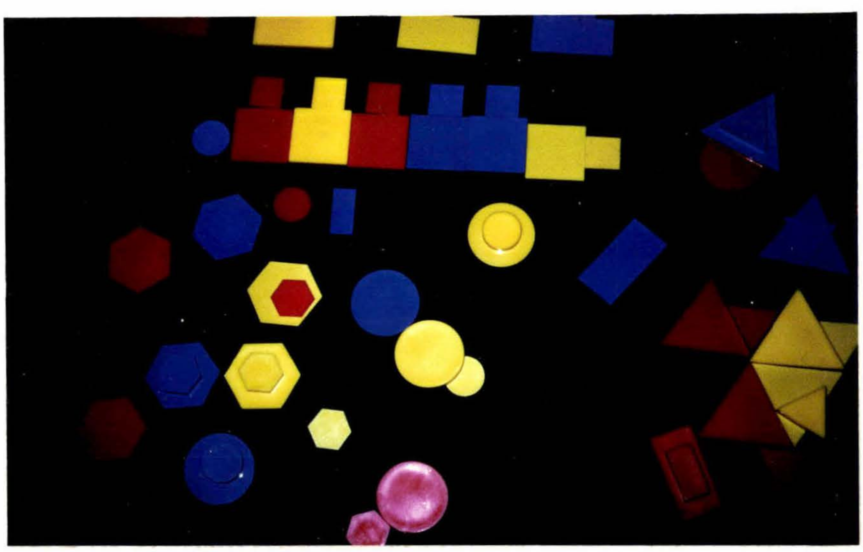


figure 21

SYNCRETIC SINGLES

figure 22

APPENDIX 1 RECORD CARD

Side 1

Name: Age: Sex: School:

ATTRIBUTE BLOCKS Number of Groups formed:

Group Number	Verbal description
1.	"I put the fat ones on the skinny
2.	ones, and made groups of the
3.	same shape - triangles here,
4.	circles, rectangles, square ones
5. etc.	and those others there".

Comments: Oldest of three. Attended pre-school. Arranged shapes as towers, large below small on top. Placed blocks in paired thick thin or thin thicks. Within size and shape. Colours not matched. Edge-matching.

Parent occupation:

Side 2

Name:

ARRAYS Number of Groups formed:

Group Number	Verbal description
1. Kangaroo and crocodile	"Animals"
2. 2 lego blocks and wheel	"Blocks"
3. Boat, bus, bike	"Transport"
4. Penny, disc, button, bead	"Circles"
5. 3 tops	"Tops"
6. Peg, sharpener, polystyrene	"Plastic"
7.	
8.	

Comments: Worked fast. As piles, no spatial arrangement. Mixed criteria.

Film No. Frame:

APPENDIX 2

THE LITERATURE OF CLASSIFICATION. PERCEPTION, STIMULUS-RESPONSE AND LEARNING THEORY.

A number of studies relating to perception were revealed by the literature search. A comprehensive review of the literature relating to perception and concept formation is to be found in Gibson, Eleanor (1957), who provides a basic guide to this complex overlapping area of research which includes classification. Haber and Hershenson (1973), have reviewed the research on vision and perception and they also provide an account of the information processing aspects of perception and classification - Haber (1964), Harris & Haber (1963), and Haber & Hershenson (1965).

For Bruner, problem-solving is a model for perception, Bruner (1957). Perception for Bruner, involves the act of categorization. All perceptual experience is necessarily the end product of the categorization process. Perception has identity as a category, the most primitive of which are innate. In "A study of thinking", Bruner et al (1956), Bruner describes how an environmental stimulus (input) is immediately categorized in terms of existing critical attributes or cues, and selectively given identity, Bruner (1957). Inference is from cue to identity, Bruner et al (1959). Bruner considers all perceptual experience as the end product of a categorization process. "Viridical perception (the match between sense data and objects), depends upon the construction of category systems" Bruner and Brunswick (1957). In other papers Bruner also describes investigations concerned with categorization and concept formation, and equivalence formation. Bruner (1959) (1964) (1966), Bruner & Olver (1963), Bruner & Potter (1964).

Other workers who have considered the development of concepts in relation to perception and categorization are Brian & Goodenough (1929), Wohlwill (1960), (1968), while the part played by stimulus information was investigated by Bourne & Parker (1964), Parker & Day (1971), and by Ginsberg, Rose (1969). In a recent book on perception and inference, Bryant (1974) takes an opposing view to those of Hemholtz, the Genevans, and the Gestalt schools of psychology. Bryant considers that a young child's perception, memory and categorization of individual objects will be heavily influenced by their relations to their surrounding frames of reference.

Many of the classification tests used in concept formation and attainment, are allied to those used by the S - R psychologists and learning theorists. An attribute such as colour may be used as a sense datum in perception tests, an attribute in concept formation, a stimulus in S - R or learning theory, and a cue in information theory. The order and presentation of the cue differs according to the requirements of a particular piece of research, but it is often extremely difficult to determine the exact nature of some of the tests without actually reading each of the papers concerned. Cue perception and discrimination learning appear to show considerable overlap and some twenty-seven papers are listed within the area. Papers by Bower (1967), Haber (1966), and Haber (1970), being mainly concerned with perception, while at the other end of the scale are those written from the learning theory perspective by Dodwell (1961), Posner & Mitchell (1967), Posner & Taylor (1964), and Estes & Taylor (1966).

One of the most powerful models for research in psychology has been provided by behaviourism in the stimulus-response paradigm. A survey of the articles on classification in this area provides us with work which falls into a number of categories - those relating to stimulus learning and discrimination, concept identification, paired associate learning, mediation responses, sequence and transfer learning, memory, and problem-solving and rule learning.

Shepard & Chang (1963) did experiments in which discrimination learning was predicted for graded stimuli. Shepard and Chang used eight Musell colour chips, the stimulus material varied along two dimensions. The eight stimuli chips were divided into two subsets of four. Here classification learning tasks required the subjects to discriminate between the two subsets. The generalization data were used to predict the difficulty of discrimination learning. The authors found that 78% error variance in classification learning could be accounted for by pairwise confusions among the stimuli, which fell into six groups. The six different kinds of classifications were not all equally difficult to learn. i.e. binary divisions with all red or yellow, were easier to learn than other classifications in which the values of two or three stimulus dimensions jointly determined the class membership of the item. Here the problem of differential coding destroyed the validity of the experiments, for at few points did the subjects match the predictions of classification learning. The match between discrimination and generalization was destroyed, Kintsch (1970). In another series of experiments, Lappin (1967) studied the identification of complex visual displays, while Goldstein & Allen (1971) investigated the effect of irrelevant stimuli on learning complex visual displays.

Concept identification is a particularly simple kind of discrimination learning. It would seem that paired-associate learning and concept identification are closely related. Reed (1946) compared the two in a series of experiments. His studies showed that despite their similarities there are important differences which are closely related to class. Suppes & Ginsberg (1962), (1963), described an experiment which, like Reed (1946), lies halfway between paired associate experiments and concept learning tasks. Suppes & Ginsberg (1962), taught children the numbers 4 and 5 in binary notation by using three different stimulus displays for each number. In such an experiment Suppes & Ginsberg (1953), taught first grade children the concept of identity of sets. The stimuli in this study were sets of one two and three elements. These experiments suggest that paired associate learning and concept identification involve different problems. A single item pair must be taken as a unit of analysis in paired-associate learning, but a whole class of equivalent items is the appropriate unit for concept learning.

Generalization and discrimination are also closely related. Generalization implies lack of discrimination and vice versa. Experiments in this area present problems both for the investigator, and in their interpretation. The way the subject perceives a stimulus was found to be an extremely important factor in such experiments. Wilkins & Epting (1971), Lappin (1967), and Goldstein and Allen (1971). Kintsch (1970), suggests that instructions and experimental payoffs may introduce response biases that play a significant role in determining experimental results.

The Kendlers, have been particularly interested in studying mediational hypotheses by comparing reversal and non-reversal shifts. Kendler, H. (1964), Kendler H. & D'Amatio (1955), Kendler, H. & Kendler Tracy (1959), (1960), (1962), and Kendler Tracy (1961). The Kendlers hypothesized that a non-reversal shift should be easier to learn than a reversal shift, according to simple S - R theory. The mediation theory in contrast, suggests that a reversal shift would be easier to learn.

In a typical reversal-shift study, subjects may be presented with a set of objects that vary along two dimensions, i.e. colour (red vs yellow) and size (large vs small). Symbolically, the four objects may be represented by R, Y (large red and large yellow) and r, y (small red and small yellow). During the initial learning period, subjects are reinforced for responding to either R or Y, the relevant dimension being size. In a second discrimination task, subjects are reinforced for responding within the same dimension (size), but now to r and y. In a non-reversal shift experiment the initial task is the same, but the second discrimination task requires a change in dimension from size to colour, with R and r being reinforced.

The Kendlers found, as hypothesized, that college students learn reversal shifts more easily than non-reversal shifts, and that rats find non-reversal shifts easier to learn than reversal shifts. They interpret these findings to mean that rats - and very young children - use simple associated techniques to learn concepts, whereas older persons use mediational responses. This conclusion has been challenged by Anderson and Ausubel (1965).

A number of studies in the area of short-term memory were concerned with grouping objects or chunking. These studies were broadly concerned with investigating the amount of material recalled. Murdoch (1961), studies recall of word triplets, or of consonants (trigrams), in groups of three. Miller (1956), demonstrated that it was the number of units or "chunks" which determines the rate of forgetting rather than the number of physical elements within an item, such as letters, or information units.

Psychologists have long known that subjects group single letters, digits, nonsense syllables, or even words, into clusters which then act as units in memory. Chunking is the result of the subject's perceptual coding process. Units stored in short-term memory are the result of very superficial perceptual processing, while those of long-term memory are based on high-level analysis, which require time and effort, Klintsch (1970). The experimenter may influence coding by arranging stimuli in ways which favour the forming of particular chunking patterns. McLean & Gregg (1967), taught subjects random sequences of letters presented in groups of 1, 3, 4, 6 or 8. They reported that subjects use a chunk size which corresponds to the grouping used in the presentation of the learning material. Miller (1956), described a number of ways in which subjects learn complex coding systems such as morse codes. He showed also that the span of immediate memory is about seven, plus or minus two chunks, and is quite independent of the size of these chunks. Wundt (1905), also used a variety of simple stimuli - lines, digits, metronome beats etc., and found the span of immediate memory to be about six "simple impressions".

In the mid-fifties a number of papers appeared which investigated clustering, often in relation to associate learning Jenkins (1952), (1958), and recall Bousfield (1953), (1956). Bousfield's work was replicated by Rossi (1964). More recent work has been concerned with the parameters of clustering, including aspects such as organization and pattern analysis McQuitty (1971) and by Schultz & Di Vista (1972), and age Wachs & Green (1971). The idea of associative clustering was strongly opposed by Bruner & Olver (1963), who suggest that the subject selects only a fraction of the properties available for grouping, and thus achieves a reduction of load. The idea of grouping by similarity or contiguity in space and time is rejected by Bruner. Some evidence <u>for</u> grouping by contiguity has come from studies by Piaget & Inhelder, Barbel (1959), and Vygotsky (1962), and Denney & Ziobrowski (1972), in their developmental studies. It would seem that very young two to four year old children group this way. It seems likely that the problem is complex and strategies may vary with age, and perhaps also between individuals.

Rule learning has been investigated by Bruner, Hunt and others. In its simplest form, instead of concepts being defined in terms of a single stimulus attribute, classifications in terms of two or more attributes are considered. The language used to describe such classifications employs logical relationships such as conjunction, disjunction, implication etc. Subjects learn to code stimulus items in terms of categories which are obtained by learning relevant stimulus attributes, and they then learn to associate these categories with the appropriate response classes. Bourne (1967) trained subjects to sort items into four classes on the basis of relevant stimulus dimensions. After three such sorting tasks subjects learned either a conjunctive, disjunctive or biconditional problem. The experiment demonstrated the efficiency of rule learning when the experimental group far outperformed the control group. Hunt et al (1966) interpreted rule learning in terms of a binary (either/or) tree system, and claimed it as an efficient method for problem solving. Bruner et al (1956), also investigated strategies for problem solving and identified a number of different strategies employed by different subjects. Suppes (1966) and Dienes (1959), relate classification tasks, problem solving and concept development within the teaching area. While some approaches are more productive than others, they tend to depend on the particular problem solving situations. A more recent development within the field has been a blossoming of studies on multiple classification using matrices. Papers by Hamel & Van Der Veer (1972), Kofsky (1968), MacKay et al (1970), McQuitty (1970), and Parker et al (1971), have resulted in some interesting experimental analysis within the field.

MASSEY UNIVERSITY
COMPUTER UNIT
S P S S - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 5.05.134

RUN NAME CLASSIFICATION AND GROUPING
INPUT MEDIUM CARD
INPUT FORMAT FIXED(F3.0,2F1.0,F2.0,4F1.0,2X,F2.0,F1.0,F2.0,3F1.0,F2.0,F1.0,1X,
F2.0,F1.0,F2.0,3F1.0,F2.0,F1.0)

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS:

VARIABLE	FORMAT	RECORD	COLUMNS
??????	F 3. 0	1	1-3
??????	F 1. 0	1	4-4
??????	F 1. 0	1	5-5
??????	F 2. 0	1	6-7
??????	F 1. 0	1	8-8
??????	F 1. 0	1	9-9
??????	F 1. 0	1	10-10
??????	F 1. 0	1	11-11
??????	F 2. 0	1	14-15
??????	F 1. 0	1	16-16
??????	F 2. 0	1	17-18
??????	F 1. 0	1	19-19
??????	F 1. 0	1	20-20
??????	F 1. 0	1	21-21
??????	F 2. 0	1	22-23
??????	F 1. 0	1	24-24
??????	F 2. 0	1	26-27
??????	F 1. 0	1	28-28
??????	F 2. 0	1	29-30
??????	F 1. 0	1	31-31
??????	F 1. 0	1	32-32
??????	F 1. 0	1	33-33
??????	F 2. 0	1	34-35
??????	F 1. 0	1	36-36

THE INPUT FORMAT PROVIDES FOR 24 VARIABLES TO BE READ FROM 1 RECORDS ('CARDS') PER CASE.
A MAXIMUM OF 36 'COLUMNS' ARE USED ON A RECORD.

```
# OF CASES      320
VARIABLE LIST   IDET,SEX,AGE,FAMSIZ,FAMPOS,SCHOOL,PRESCH,OCC,GRPNO1,CRIT11,CRIT12
                ,CAT1,LOGIC1,SORT1,CRIT13,ERR1,GRPNO2,CRIT21,CRIT22,CAT2,LOGIC2,
                SORT2,CRIT23,ERR2
VAR LABELS      IDET,IDENTITY/FAMSIZ,CHILDREN IN FAMILY/FAMPOS,POSITION IN FAMILY
                /PRESCH,PRESCHOOL ATTENDANCE/OCC,OCCUPATION/
                GRPNO1,NO OF GROUPS BLOCKS/CRIT11,NO OF CRITERIA BLOCKS/
                CRIT12,CRITERIA USED BLOCKS/CAT1,CATEGORIZER BLOCKS/
                LOGIC1,LOGIC BLOCKS/SORT1,SORTING BLOCKS/
                CRIT13,CRITERIA BLOCK ATTRIBUTES/ERR1,SORTING ERROR 1/
                GRPNO2,NO OF GROUPS ARRAY/CRIT21,NO OF CRITERIA ARRAYS/
                CRIT22,CRITERIA USED ARRAYS/CAT2, CATEGORIZER ARRAYS/
                LOGIC2,LOGIC ARRAYS/SORT2,SORTING ARRAYS/
                CRIT23,CRITERIA ARRAY ATTRIBUTES/ERR2,SORTING ERROR 2/
FASTABS         VARIABLES=SEX(1,2)/GRPNO1(1,31)/CRIT11(1,4)/CRIT12(1,11)/
                CAT1(1,3)/LOGIC1(1,4)/SORT1(1,5)/CRIT13(1,13)/ERR1(1,2)/
                GRPNO2(1,30)/CRIT21(1,4)/CRIT22(1,11)/CAT2(1,3)/LOGIC2(1,4)/
                SORT2(1,5)/CRIT23(1,11)/ERR2(1,2)/TABLES=GRPNO1,CRIT11,CRIT12,
                CAT1,LOGIC1,SORT1,CRIT13,ERR1,GRPNO2,CRIT21,CRIT22,CAT2,LOGIC2,
                SORT2,CRIT23,ERR2 BY SEX
STATISTICS      1,3


READ INPUT DATA
END OF DATA INPUT, READ COUNT =320 DATA ERROR COUNT = 0.
```