THE DEVELOPMENT OF THE CONCEPT OF CONSERVATION IN AUSTRALIAN ABORIGINAL CHILDREN

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Two glasses are set in front of the subject - a long, thin glass and a short, wide glass.

While she watches, one full measure of sugar is poured into the long thin glass, and one full measure plus a further half measure is poured into the short wide glass.

The level of sugar is higher in the long glass.

The subject is asked to choose which sugar she wants.

She takes the sugar from the long thin glass and pours it into her cotton bag.

(See Appendix 4)

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ABSTRACT

This study describes the application of Piaget's tests of conservation of quantity, weight, volume, length, area and number to two groups of Aboriginal children living on mission stations in the Northern Territory of Australia.

The first part of the thesis is devoted to a consideration of the theoretical background of the study. In the first chapter Piaget's general theory of intellectual development is outlined, and the problem of the comparative study of intellectual development is considered. It is pointed out that little research in this area has been undertaken, and reasons for this neglect are suggested. Levy-Bruhl's theory of primitive thinking is reviewed, and the parallels between the theories of Piaget and Levy-Bruhl are discussed. It is suggested that the techniques developed by Piaget in his study of the intellectual development of children could be applied to the study of intellectual development in primitive peoples, and that these techniques could be used to test Levy-Bruhl's theory. The implications of Piaget's theory and its relation to other problems in psychology are also discussed.

In the second chapter the theoretical basis of the tests used in the present study is outlined, and in Chapter III a number of related studies are reviewed.

The second part of the thesis deals with the study itself.

In Chapter IV the cultural background, living conditions and general activities of the Aboriginal people are described. It is pointed out that the traditional life of the Aborigines was extremely simple, and that their present housing, health, nutrition and educational standards are considerably below those of the white Australian. Since it has been shown that the environment can influence intellectual development, these factors are relevant to the study of conceptual development in Aboriginal children. The games and leisure activities of the Aborigines are also described, since these may indicate the types of thinking required and used in the society. Some studies on the intellectual capacity of the Aborigines are reviewed, and the characteristics of Aboriginal languages are discussed.

Chapter V deals with the actual testing procedures, in Chapter VI the results of the study are reported, and in Chapter VII the qualitative results are described and discussed.

It was found that the concept of conservation develops much later in Aboriginal than in European children, and that in some cases non-conservation was still found up to the age of 15 years. However, the stages of development and the explanations and justifications for correct and incorrect responses were the same as those reported by Piaget. There was a close correspondence between the results of the two groups tested, although some differences were found.

Significant differences were found between the full-blood and the part-blood children tested at the Hermannsburg mission.

A scalogram analysis applied to the results indicated that the tests were scalable by Guttman's criteria, and Loevinger's test for homogeneity yielded high homogeneity co-efficients. However, some divergences from the invariant order postulated by Piaget and Inhelder were found. An analysis of the non-scale patterns of response obtained was made.

In the final three chapters the results of the study and their implications are discussed.

In Chapter VIII the order of difficulty of the tests, the later development of conservation in Aboriginal children, and the differences between the Elcho and the Hermannsburg groups are discussed in relation to the effects of experience on the previous tests and environmental influences. The factors of intelligence and maturation in intellectual development are also considered, and the significant differences between the full-blood and the part-blood children and the question of racial differences in intelligence are discussed.

In Chapter IX Piaget's theory is examined in the light of our findings and those reported by other investigators. Some of the problems that have been raised by these studies are considered, and an attempt is made to clarify these problems and to point to those aspects which require further investigation. An alternative interpretation of the findings reported is also discussed.

In the final chapter the general implications of our findings are considered, some linguistic and methodological problems of cross-cultural studies are discussed, and suggestions are made for future research.

We find that our results confirm Piaget's general theory of intellectual development, but that further research is required to determine whether or not there is an invariant order for conceptual development. Our results also appear to support Levy-Bruhl's theory of primitive thinking, but further research on the logical thinking of adult Aborigines would be required to confirm this.

The implications of our findings for Aboriginal intelligence and education are also considered. It is pointed out that the question of possible racial differences in average intellectual potential does not have important implications, since it would not be expected that such differences would be absolute, and considerable overlap in intellectual potential between different racial groups would be expected. However, it is suggested that the actual differences found between Aborigines and Europeans in the rate of intellectual development and the final level of mental functioning achieved does have important implications, since an unfavourable environment in early life may have permanent and lasting effects.

Emphasis has therefore been placed on the importance of investigating what aspects of the environment influence development, what experiences will lead to most rapid development, and to what extent appropriate experiences at the adult level can overcome the handicaps of a poor environment in early development.

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INTRODUCTION

This study investigates the development of the concept of conservation in Australian Aboriginal children. It is based on the work of Piaget, and its purpose is primarily to determine whether the stages of development described by Piaget occur in children from an entirely different cultural background to that of the Western European child.

Piaget has described intellectual development as proceeding through a series of stages. Each stage marks a particular level or mode of thinking, which determines the child's ability to deal with concepts and problems in a number of different areas. Each stage develops as a result of the increasing organisation and systematisation of thought processes, and depends on the integration of the achievements of previous stages with succeeding stages. From this it follows that:

1. The appearance of a particular stage of development will affect the child's ability to deal with a wide range of concepts.
2. The order of successive stages of development must remain invariant.

Piaget maintains that the structures of thought are determined by three main factors:

1. Maturation of the nervous system.
2. Experience acquired in interacting with the physical environment.
3. The influence of the social milieu.

However, he states that these factors are limited by the laws of equilibrium, which are determined by the biological structures and functions of the human organism. Since these structures and functions are independent of society, Piaget maintains that while the physical environment and the social milieu may modify development to some extent, development must necessarily follow the same pattern. He therefore maintains that the stages of development he has described will occur in all societies, and that the order of succession of these stages must be invariant. But since development also depends on the social and physical environment, societies may vary with regard to the average ages at which these stages are achieved, and in some societies the higher levels may not be achieved at all.

The aim of this study is therefore to test Piaget's hypothesis that the same stages of development will occur in Aboriginal children as in European children, and that these stages will follow the same order of succession as in European children.

This study is essentially exploratory, since prior to carrying out the testing it was not known whether or not Piaget's techniques could be successfully applied to Aboriginal children, or what particular difficulties of understanding or interpretation might occur as a result of the different cultural and linguistic background of the children.

The thesis is divided into two main parts. The first part is devoted to a consideration of the theoretical basis of the study, and the second part is devoted to the study itself. In a final section the general implications of the study will be considered.

PART I

THEORETICAL BACKGROUND

CHAPTER I

GENERAL THEORETICAL BACKGROUND OF THE STUDY

Chapter I is divided into three main sections.

The first section will be concerned with Piaget's general theory of intellectual development.

The second section will be concerned with the problem of the comparative study of intelligence. This will be divided into three main parts:

1. The general problem of comparative studies.
2. Levy-Bruhl's theory of primitive thinking.
3. A discussion of the relation between the theories of Piaget and Levy-Bruhl.

The third section will be concerned with the general implications of Piaget's theory and its relation to general problems in psychology.

I. PIAGET'S GENERAL THEORY OF INTELLECTUAL DEVELOPMENT

Piaget (1953) regards intelligence as a particular form of adaptation, which occurs as a result of the child's interaction with his environment. He states that this intelligence is at the same time an organisation, adaptation being the external aspect and organisation the internal aspect of the same mechanism. The function of adaptation and organisation, or intelligence, is to structure the universe, just as the organism structures its immediate environment. Piaget states that intellectual adaptation concerns the relationship of thought to things, and its purpose is to construct mental structures which can be applied to the environment.

While the structures of thought created by intelligence are variable, becoming increasingly complex in the course of development, the functions of adaptation and organisation remain invariant, and are continuous with biological functions.

Organisation is the invariant function by means of which all intellectual acts, from the most primitive sensori-motor acts to the most advanced operational acts, are co-ordinated and interrelated to form systems of relationships or totalities. Organisation is present at every level of intellectual functioning, and its laws are independent of the particular structures involved.

In the case of adaptation, two complementary processes are distinguished; assimilation and accommodation. In the biological sense assimilation involves the incorporation of elements of the environment into the organism itself, as for example in the ingestion and digestion of food. In the intellectual sense, assimilation occurs when the individual reacts to new objects and features of the environment in the same manner as he has reacted to similar objects and features in the past. The new objects are thus assimilated to familiar objects and to known behaviour patterns. This would correspond to generalisation.

Accommodation, in the biological sense, refers to the actions taken by the organism to adapt itself to the environment. In the intellectual sense, accommodation occurs when the behaviour of the individual is changed in response to new situations in the environment, and these changes result in modifications of the thought structures which determine behaviour. This corresponds to differentiation.

Piaget states that development proceeds by means of the complementary processes of assimilation and accommodation. While he maintains that these two processes are always associated, neither occurring without the other, he states that there can be primacy of one process over the other. Initially there is primacy of assimilation over accommodation, the child's first activities being essentially assimilatory and concerned mainly with incorporating external objects into his established schemas. With the increasing demands of the environment accommodation progresses and becomes more dominant, leading to changes in behaviour and the differentiation and creation of new schemas of thought.

Where there is primacy of assimilation, there is repetition of behaviour for its own sake, as in play. Where there is primacy of accommodation, behaviour is purely imitative. Where assimilation and accommodation are in equilibrium, there is intelligent adaptation.

The structures of thought are defined in terms of 'schemas'. Schemas are observed as particular patterns or sequences of behaviour, which imply the presence of a particular cognitive structure or organisation such that this pattern of behaviour will always appear under particular conditions as a behavioural totality. While schemas are defined in terms of observed behaviour patterns, they imply or assume a particular mental structure or organisation which determines behaviour and thought processes. These schemas develop from the simple sensori-motor schemas controlling the behaviour of the infant, such as sucking and grasping, to the extremely complex schemas of formal operational thinking. This development proceeds by the repetition, generalisation and differentiation of the schemas through the adaptive processes of assimilation and accommodation, and the combination, co-ordination and integration of the schemas through the function of organisation.

Piaget (Inhelder and Piaget [1958]) states that the growth of thinking can be described from two distinct and complementary points of view. The first is that of equilibrium conditions, the second is that of structure formation.

From the point of view of equilibrium, intellectual development occurs as thought processes tend towards states of increasingly stable equilibrium through a variety of specific forms. He states that the laws of equilibrium 'express the probability of the occurrence of various possible forms of compensation in function of the neuro-physiological conditions, physical environment, and social milieu' (Inhelder and Piaget [1958] p.243).

Piaget's theory of equilibrium is exceedingly complex, and cannot be dealt with here. An exposition of this theory has been given by Flavell (1963).

From the point of view of structure, Piaget studies both how the particular cognitive structures arise, and how they follow one another along the genetic series. He maintains that the formation of the structures depends on three main factors:

1. Maturation of the nervous system.
2. Experience acquired in interaction with the physical environment.
3. The influence of the social milieu.

It can therefore be seen that both from the point of view of equilibrium, which determines the development from one stage to the next, and from the point of view of the particular structures that develop, Piaget considers development as a function of the three factors of neuro-physiological maturation, physical environment, and social milieu. However, he sees the latter factors as limited by the laws of equilibrium, which determine the best forms of adaptation compatible with the sum of the operant social and physical conditions.

The form of the intellectual structures and the equilibrium of each stage of development is therefore ultimately dependent on the genetic biological structures of the organism and the invariant biological functions of organisation, assimilation and accommodation. While the physical environment and the social milieu may modify development to some extent, development must necessarily follow the same pattern determined by the biological structures and processes of the human organism.

Stages of Development

Piaget distinguishes two main levels of intelligence, the sensori-motor level and the operational level.

1. Sensori-motor Intelligence

Sensori-motor intelligence is developed during the first two years of life, being finally achieved at about two years when the first stable equilibrium between assimilation and accommodation is attained.

During this period the child builds up a practical knowledge of his world, learning to differentiate between himself and external objects, and locating these objects and himself within a stable system of reference. At this level the child is limited to dealing only with his immediate environment, since he is still dependent on perception, which is necessarily immediate, subjective, and directly related to his own actions.

Piaget lists three main characteristics of sensori-motor intelligence that distinguish it from operational thought (Piaget [1950] pp.120-1).

1. Acts of sensori-motor intelligence consist solely in co-ordinating successive perceptions and successive overt movements, and can therefore only be reduced to a succession of states, linked by brief anticipations and reconstructions, but never arriving at what Piaget terms an 'all embracing representation'. Such a representation can only be established when the development of thought enables these states to exist simultaneously, and so releases them from the temporal successions of perception and action.

2. An act of sensori-motor intelligence leads only to practical satisfaction; that is, to the success of an action, and not to knowledge as such,

> It does not aim at explanation or classification or taking note of facts for their own sake; it links causally and classifies and takes note of facts only in relation to a subjective goal which is foreign to the pursuit of truth. Sensori-motor intelligence is thus an intelligence in action and in no way reflective (Piaget [1950] p.121).

3. Sensori-motor intelligence deals only with real entities, and each of its actions involve only very short distances between subject and objects. While it may be capable of detours and reversals, it never concerns anything but responses actually carried out and real objects. It is only with the advent of representative thought that the child is able to break away from these short distances and physical pathways, and to deal with not only what is invisible but with what can only be imagined or hypothesised. Thus it is only conceptual thought that enables the child to go beyond the immediate and real world.

2. Operational Intelligence

The operational level of intelligence begins to develop with the appearance of the image and representational thought, which allows the child to take into account not only the immediate present situation, but also memories of past and possibilities of future situations.

Two main periods are distinguished at the operational level:

1. The period of concrete operations, from 2 to 11 years.

During this period concrete operations, dealing with the organisation and systematisation of empirical data, are gradually built up and organised into systems.

This period is usually divided into three states:

1. Pre-conceptual thought.
2. Intuitive thought.
3. Concrete operational thought.

2. The period of formal operations, from 11 to 15 years.

During this period the concrete operational systems are co-ordinated and integrated into a combinatorial system which enables the child to go beyond the organisation of empirical data, as found at the concrete level, and to fit the empirical data immediately into systems of potential transformations. This leads to the development of hypothetico-deductive reasoning.

Characteristics of Pre-conceptual Thought

According to Piaget (1951), the pre-concepts which precede operational concepts, are characterised by a lack of individual identity and a lack of general classes. The lack of individual identity is shown by the fact that an individual may be thought to change according to the particular situation, or may be thought to be identical to a similar object. Thus only distinct successive stages are recognised, and not identity through time.

The lack of general class is seen in the fact that at this level a 'class' is merely a typical individual reproduced in several copies, e.g., the slug (Piaget [1951] p.225).

Piaget argues that the lack of individual identity and the lack of general classes is in fact the same thing. It is because the stable general class does not exist that the individual elements, since they cannot be identified with the general class, are identified directly with one another, and are without permanent individuality; and it is the lack of individuality of the parts that prevents the whole from becoming an inclusive class. It is in this sense that he states that the pre-concept is 'half-way between the individual and the general' (Piaget [1951] p.226), and that it is not yet completely differentiated from the image, since it represents not just any object, but a particular typical individual. This is in contrast to the operational concept, which 'breaks away from the image and uses it only as an illustration' (Piaget [1951] p.229).

He maintains that it is the nature of the pre-concept which prevents the child at this level from achieving operational modes of thought. Because the pre-concepts cannot be formed into general inclusive classes, the relationships between pre-concepts do not form true relations, but form 'participations' in Levy-Bruhl's sense (see p.32) which Piaget defines as 'absence of inclusion of the elements in a whole, and direct identification of partial elements one with another, without the intermediary of the whole' (Piaget [1951] p.226).

The types of reasoning found at this level are termed symbolic and pre-conceptual reasonings. These are closely related to the co-ordination of schemas of action that characterise sensori-motor intelligence, and are merely a continuation, on the representational plane, of the practical co-ordinations found in the infant after the first year. In both cases, Piaget says, 'it is merely a question of achieving an aim and of finding adequate means for so doing' (Piaget [1951] p.233).

Piaget makes two important distinctions between symbolic reasoning and practical co-ordinations.

1. The child does not confine himself to reasoning by action, but uses images and words to evoke the end in view and the means to be used.
2. Because representation enables him to go beyond the perceptual field, he can distort the reality represented to suit his wishes, and subordinate it to the aim he wants to achieve.

The first reasonings are influenced by desire and result in distortions of reality. These Piaget relates to symbolic or ludic thought. Later, recognitive or reflective reasonings appear which are not influenced by desire, but consist in relating recognition judgements one with another and drawing a conclusion not desired in advance. Both these types of reasoning depend on transduction; i.e., reasoning from the particular to the particular.

Piaget distinguishes here between empirical or external truth, and logical or internal truth. He points out that while the former may be found in pre-conceptual thought, the latter is found only in logical thought.

Transduction is defined as: 'an inference which is non-regulated (non-necessary), because it bears on schemas which are still half-way between the individual and the general' (i.e., pre-concepts) (Piaget [1951] p.234). These schemas do not contain the reversible nestings of a hierarchy of classes and relations, and transductive reasoning is therefore a system of co-ordinations without nestings, and with direct connections between semi-particular schemas. For this reason, when reasoning involves only practical schemas, that is, schemas generalised through previous actions and bearing on individual objects, or when it involves only extremely simple compositions where decentration automatically occurs, transduction will lead to a correct conclusion. Such reasonings may have all the appearances, verbally, of a logical deduction, but they are due merely to the empirical bringing together by action of earlier experiences. Where the reasoning requires nestings of classes or compositions of relations, transduction is unable to give a correct conclusion through lack of a general system of classes and relations depending on a reversible operational mechanism.

During the intuitive phase of pre-operational thought the various characteristics of the pre-concept tend towards the operational concept through the gradual construction of a hierarchy of nestings. At this level the child is able to achieve partial constructions by means of 'articulated intuitions'. These are still linked with the perceptual configuration and with the image, but are already logical within this restricted field. (For example, conservation that occurs so long as it is supported by a perceptual one-one correspondence, but which breaks down as soon as the perceptual correspondence is broken down.) The construction of complete hierarchies of nestings is only achieved when the concept is completely differentiated from the image, enabling it to achieve complete generality and therefore to be organised into a system of classes consisting of individual elements. This can only be achieved when operations become reversible.

The structures of intuitive and concrete operational thought will be covered in the discussion of Piaget's tests on conservation in Chapter II.

The structures of formal thought are beyond the scope of the present study.

II. THE COMPARATIVE STUDY OF INTELLIGENCE AND THINKING

1. The General Problem of Comparative Studies

The study of intellectual development and conceptual thought in cultures other than our own has been largely neglected up to the present time. There would seem to be three main reasons for this neglect. First, ideological reasons; second, lack of suitable techniques; and third, the influence of psycho-analytic theory in anthropological studies. Each of these causes will be examined further in some detail.

Ideological Causes

Views on the comparative intelligence of different races are closely bound up with political and ideological principles. In the past, the popular view that there were hereditarily determined differences in intelligence between races was supported on the basis of such principles. Today the view that there are no racially determined hereditary differences in intelligence is politically and ideologically popular.

The ideological and political implications of this problem have tended to interfere with the objective assessment of the actual evidence with regard to possible differences in intelligence between races.

In 1950 U.N.E.S.C.O. issued a statement on the nature of race and race differences, designed to define the concept of race and to summarise scientific knowledge on the question. The statement gave rise to considerable criticism, particularly by physical anthropologists and geneticists. In 1951 a revised statement was drawn up and circulated to a number of anthropologists and geneticists for comment. This revised statement, together with the comments and criticism of these scientists, was published in 1952 (U.N.E.S.C.O. [1952]).

The discussion and comments on this statement clearly reveals the ideological influences in this controversy. Some of the comments expressed reservations as to the desirability of a political body elevating scientific findings and opinions to the status of accepted doctrines. This point was made by Fischer (ibid., p.32), and also by Scheidt, who wrote: 'I can have no part in attempts to solve scientific questions by political manifestoes...' (ibid., p.32).

Other comments expressed reservations or criticisms of the substance of the statement. The most important of these criticisms was that made by Muller, who objected to the implication in the statement that there were no racial differences in mental characteristics. He pointed out that genetic differences existed in physical characteristics, and there was no reason to suppose that similar differences did not also exist in mental characteristics. He argued that there was no need for the argument against racial prejudice to be based on the false assumption that the genetic bases of intelligence are equal in all races, and that to do so would leave the statement open to attack. Similar views were expressed by other commentators.

The ideological difficulties associated with the discussion of this problem have been referred to by Morant (1956), who states:

> Anyone who enunciates this conclusion (i.e., that there are racial differences in mentality) is liable to be misunderstood; discussion of the problem has always tended to run to extremes. On the one hand there have been writers who asserted that there are racial differences of profound significance, and opposed to them have been others who have vehemently denied the existence of any inborn inequalities between groups of people. Few have argued that both these parties are in error. Any admission of racial differences is suspected by the 'levellers' to have a sinister implication, and the proponent of it is likely to be suspected of claiming superiority for the group to which he belongs (Morant [1956] p.324).

Morant points out that if mental characteristics showed identical distributions for all racial populations, 'that would be a situation unparalleled, as far as is known, as regards any physical character in man or in any other animal' (ibid., p.320). He states that the tendency has been to progressively minimise the significance of racial differences, and that the ultimate solution of the problem seemed to be leading toward a denial of the existence of any racial differences. This, he states 'is manifestly untrue in the case of physical characters, and in the writer's opinion is very unlikely to be proved true in the case of mental qualities' (ibid., p.324).

Psychologists' discussions on racial differences in intelligence have centred on the question of the proportionate influences of heredity and environment. Klineberg (1956) argues that since racial differences on test scores tend to disappear as environmental backgrounds become more alike, these differences must be due to environmental differences rather than to racial differences. A similar view is taken by Myrdal (1944). Biesheuval (1952) points out that this argument is based on the erroneous assumption that because inferences with regard to environmental factors are positive, those with regard to heredity must be negative. While there is evidence that environmental factors do influence intellectual development both quantitatively and qualitatively, Biesheuval points out that it has not been proved that all differences vanish when environment is held constant. He states that heredity and environment are complementary, and both contribute to individual differences in ability within racial groups, and he suggests that the more fundamental research problem is a study of the way in which the cultural environment determines mental development.

The same point is made by Hunt (1961) who has shown that the question of the proportionate contributions of heredity and environment to intellectual development has no general answer. He points out that the analysis of variances model that has been used in relation to this question is inadequate, since it rests on the false assumption that variances due to heredity and to environment are additive and without interaction. He quotes Loevinger's (1943) criticism of this model in support of this view. Evidence of the interaction between environment and heredity has been clearly demonstrated. Hunt cites recent evidence from genetics which indicates that the environment can produce fundamental changes from genotype to phenotype; in mosquitoes changes of sex can be induced according to the temperatures to which the larvae are exposed. Hunt also points out that there is no direct link between the genetic basis and the final level of intelligence achieved, and the number of steps that are required and the manner in which each of these steps may be affected by the environment is not known. He suggests that the question first posed by Thorndike as to the proportionate influences of heredity and the environment was an unfortunate one, and that a more sensible strategy is to ask specific questions related to specific theoretical issues or to specific practical problems. Such questions would relate mainly to how experience influences development, and Hunt maintains that in studying <u>how much</u> experience influences development, we will necessarily come to discover the answer to the question <u>how</u>?.

The controversy on racial differences in intelligence has centred on the question of <u>potential</u>

intellectual capacities. Little attention has therefore been directed to the question of the actual differences observed, or to the investigation of how the observed differences may be related to particular environmental or cultural conditions. Ideological considerations have tended to inhibit the thorough investigation of these observed differences, since such studies would draw attention to the differences between races rather than the similarities. As a result, little progress has been made in the investigation of precisely what differences do occur between races, and how and to what extent the environment affects these differences.

Lack of Suitable Techniques

The most widely used techniques for the study of intellectual functions are those that have been devised and used in the traditional intelligence and aptitude tests. While it is clearly recognised that actual intelligence test scales are strictly comparable only within the criterion group, and that these tests cannot be used to compare intelligence or intellectual development between different cultures, these tests have, until recently, been the only recognised methods of studying intellectual capacities and abilities. As such, they have been widely used in cross-cultural studies (Porteus [1931] Fick [1939] Kennedy, van de Riet, and White [1963]). While other techniques, particularly those based on the work of Piaget, are now being developed, the traditional intelligence test techniques and the theory underlying these techniques have had and continue to have considerable influence on views with regard to intelligence and intellectual development in other cultural groups. Biesheuval (1952) for example, has proposed that African abilities should be studied by means of detailed qualitative observations of how their abilities are expressed in their own cultural context, followed by a systematic study of these abilities using the traditional types of intelligence tests.

In our view progress in the study of intellectual processes and development in other cultures has been hindered by the inadequacies of the intelligence test techniques and the theory underlying these techniques. The two main inadequacies of these techniques seem to be the following:

i) The concept of the I.Q., on which these techniques are based, and the emphasis on the use of these tests for predictive purposes, assumes that intelligence is fixed. The theory underlying intelligence testing therefore fails to recognise or account for the influence of the environment in intellectual development, and variations in environment are considered to be an extraneous variable which must be controlled or excluded. When intelligence tests are applied to other cultures it becomes quite clear that performance on the tests is dependent on the particular cultural environment and it is therefore difficult to interpret or to evaluate the results of such tests.

Hebb (1949) points out that intelligence testers have been reluctant to accept the evidence of major effects of experience on I.Q., because this would seem to deny the validity of the intelligence test method.

However, he maintains that if the principle of a lasting and generalised effect of early learning is accepted, the validity of intelligence tests is not reduced, and may in fact be extended to show in what sense a test is valid and in what sense it is invalid.

Hebb distinguishes two meanings of the term intelligence; an innate potential for intellectual development, which he terms intelligence A, and the actual level of mental functioning achieved, which he terms intelligence B. The question as to whether intelligence is determined primarily by heredity or by environment is actually a question of the relation between intelligence A and intelligence B. Experience cannot affect intelligence A, but only intelligence B. He maintains that much of the controversy on this question has arisen from a failure to distinguish clearly between these two uses of the term intelligence.

The I.Q. is usually considered as a measure of innate or hereditarily determined intelligence. Hebb points out that in fact intelligence test scores are primarily related to intelligence B, and are only indirectly related to intelligence A. He states that in most cases intelligence test scores are a valid measure of intelligence B and can be used for predictive purposes. This is because the effects of early experience tend to be permanent and lasting. It is only if test scores are assumed to be a measure of intelligence A that they can be considered invalid in cases where the environmental backgrounds of the subjects differ, as in the case of negro and white. However, he points to the inconsistency of regarding I.Q.

scores of white children as valid measures of intelligence A, but not those of negro children, when in fact differences between white children's environments can be as great as those between white and negro children. He maintains that the argument that I.Qs. are not valid for negro children because of environmental differences completely undermines the argument that I.Qs. are valid measures of hereditarily determined intelligence in the case of white children.

ii) Intelligence tests have been selected on a pragmatic basis, and little study has been made of the actual thinking processes required for the solution of problems involved, the reasons for failure on any of the tests, or the relationships between performance on different tests. (An exception is the recent work of Donaldson [1963]) The tests are selected because they have been found in practice to distinguish successfully between individuals who are likely to succeed in certain future situations, and those who are not likely to succeed in such situations. When these tests are applied to other cultures, success or failure on particular problems yields no clear information as to the presence or absence of particular types of thought processes, nor any information on whether failure on different tests can be related to one specific type of thought process or to different types of thought processes. Thus the results of intelligence tests can give us little understanding of or insight into the particular characteristics of the thought processes of other cultures.

It is true that intelligence and aptitude tests can be devised for other cultures which do successfully distinguish between individuals of that culture who are likely to be successful in a particular situation, and those who are not. In so far as intelligence tests are devised for particular practical purposes they may well prove to be useful and valuable techniques, for example, for selection in industrial and educational situations. However, they are at present inadequate as a technique for the study and investigation of conceptual thought processes, or as a basis for theoretical interpretations regarding the relative intelligence of different cultural groups.

The Influence of Psycho-analytic Theory in Anthropological Studies

Freudian and psycho-analytic theory has had a strong influence on cultural anthropology, even among those anthropologists who have claimed that their theory does not rest on psychology. This point has been particularly clearly demonstrated by Wallace (1962) with reference to Radcliffe-Brown's theory of functionalism. This has led to an emphasis on the study of unconscious and affective thought processes to the neglect of conceptual and logical thought. Anthropological studies of representative thought have concentrated on studies of the mythology and the religious beliefs and customs of other cultures, which have been related to psycho-analytic theory. They have therefore emphasised the similarities between the affective and unconscious thought processes in different cultures, and ignored the differences in logical and conceptual thought that would seem to occur.

These three main reasons accounting for the neglect of the study of conceptual thought in other cultures are clearly interrelated. The failure to develop suitable techniques no doubt results from the reluctance of psychologists to take up this problem because of its ideological implications. The anthropologists' preoccupation with psycho-analytic theory may be partly accounted for by the fact that no other acceptable psychological theory or technique was available to them. The emphasis on potential abilities rather than actual abilities is probably as much a result of the influence of intelligence test theory as of ideological factors.

This neglect of the comparative study of conceptual processes has persisted fairly generally up to the present time. There are, however, indications that the recent renewed interest in thinking and cognition among psychologists is likely to have its effect in this field too. Wallace (1962) in summing up the papers given at the 1960-1 series of lectures before the Anthropological Scoiety of Washington, remarks that the most prominent trend of the lectures was the emphasis on cognitive processes, which appeared in one or another aspect in every one of the papers given. He relates this emphasis to the changing trend in culture-and-personality theory, which is moving away from the old emphasis on personality and psycho-analytic theory, to a new emphasis on cognitive processes. This change has been stimulated mainly by new developments in psychological and linguistic theory, and has led to the development of new methods of analysing the linguistic systems and folk classifications of different cultures. This new field has been termed the 'ethnography of speaking' (Hymes [1962]) or 'ethnoscience' (Sturtevant [1964]) and it is based on the methods of descriptive linguistics.

2. Levy-Bruhl's Theory of Primitive Thinking

The theory of primitive thinking put forward by Levy-Bruhl is perhaps the only attempt to provide a general theoretical framework for understanding the processes of primitive thinking and the laws which govern these processes, and relating primitive thought to that found in our own culture.

His theory is also of particular interest to this study, since it bears certain close parallels with Piaget's theory of the development of thought processes in the individual. If a parallel can be established between intellectual development in societies and intellectual development in individuals, this could contribute to our understanding both of the mechanisms by which thought develops, and the nature of the particular types of thought processes found in children, primitive peoples, and the scientific thinking of our own society. The theories of Levy-Bruhl and Piaget may therefore provide a theoretical framework through which our findings on Aboriginal children can be related to the problem of conceptual development in individuals and in societies.

Levy-Bruhl's first publication on his theory of primitive thought appeared in 1910, and subsequent volumes appeared in the period 1922-31. English translations of his works appeared in 1923 and in 1928. The following discussion of his theory is based mainly on the English translation of his first work, entitled 'How Natives Think' (1928).

His theory was put forward in opposition to the views currently held by anthropologists at that time, particularly the views of the English school of anthropology which was represented by the writings of Tylor and Fraser. It gave rise to much comment and criticism at the time, but today it appears to be largely ignored, and few references to his ideas are to be found in recent anthropological or psychological writings on primitive thought appearing in the English language. In view of this it would seem necessary not only to present a brief review of his theory, but also to examine some of the main criticisms which have been made against it, and the reasons why his ideas have been rejected.

Levy-Bruhl bases his theory on an examination of the 'collective representations' of primitive societies. He defines the 'collective representations' as the language, traditions, customs, myths, and beliefs which are common to all the members of a society and which are transmitted from generation to generation, being impressed upon each individual by the society.

He maintains that by studying the 'collective representations' of the most primitive societies known, and comparing these with those of our most advanced societies, we may hope to arrive at a knowledge of the laws which govern these representations, and thus to better understand and interpret the mentality of primitive people and our own.

This position is based on the argument that a particular society, with its own institutions and customs, will necessarily have its own mentality. While he accepts that there are features which are common to all societies, and that therefore the higher mental operations in all societies will have a certain basic homogeneity, he maintains that the profound differences that exist between societies will result in corresponding differences in the higher mental processes.

His main thesis is that the various characteristics of primitive thought are based on a lack of differentiation between the cognitive aspects of a representation, and the emotional and motor elements which are associated with it. In our society a 'representation' denotes an intellectual or cognitive process, which is dissociated from motor and affective elements. In the collective representations of primitives, he finds that the motor and affective elements form an integral part of the representation, and the intellectual aspects cannot be dissociated from them. Thus any idea, image, or object possesses, for the primitive, not only an intellectual aspect, but motor and affective aspects. These are not differentiated, and all are considered as real and as much a part of the object or idea as the others. It is in this sense that the representations of primitive thought are said to be undifferentiated. Only by a gradual process of differentiation do the intellectual and physical aspects become distinguished and separated from the affective and motor aspects, allowing the development of more complex intellectual operations.

Levy-Bruhl describes primitive thought as essentially mystical and pre-logical. These characteristics are intimately linked with the lack of differentiation found in primitive thought.

The term mystical is used to define all those aspects of primitive thought relating to the belief in 'spirits', 'influences' or 'forces'. In the collective representations of primitive societies, virtually all objects and beings are endowed with certain powers or influences. The importance of these influences is strongly emphasised and impressed upon individual members of the society, particularly on the occasion of ceremonies and rituals such as the initiation ceremonies, which are of great importance in the life of the individual and therefore have a great influence on him and on his thinking. The degree to which such ceremonies are used to impress and enforce ideas on the individual by the society, and their effects, have been discussed by Sargent (1957).

Levy-Bruhl attempts to show how the mysticism inherent in the collective representations of primitives, together with the lack of differentiation of primitive thought, accounts for many of the characteristics of primitive thinking that have been observed and recorded.

He argues that because the primitive fails to distinguish between the objective or physical properties of objects or beings, and the affective and mystical properties with which these objects have been endowed in the collective representations of the society, and because the collective representations of the society tend to emphasise the mystical properties of objects rather than the physical, primitive thought follows a different emphasis and a different orientation to that found in our societies.

The difference in emphasis is due to the greater importance that is attached to the mystical properties of objects. For example, the totem is based on the idea that all members of a totem are linked together by mystic properties, and because these properties are more important than the physical properties, the physical differences between members of the same totem become relatively unimportant. Similarly, the distinction between animate and inanimate is less important, since both may have equally important and powerful influences. New and unfamiliar objects may cause suspicion and fear, since these have unknown mystic properties which may be evil and powerful. In the same way, the mystic properties attributed to various objects, implements, weapons, organs of the body, and such things as names, shadows, and pictorial or symbolic representations, are more important than their physical properties.

Since all occurrences can be attributed to the mystical influences exerted by various objects or beings, there is no need for the primitive to look for explanations for natural phenomena, since the mystic properties in themselves constitute the explanation. Levy-Bruhl states that it is only at a later stage that the mystic properties are detached from the natural phenomena, and become an explanation for them.

Levy-Bruhl argues that it is this difference in emphasis that produces also a difference in orientation. While we are oriented to looking for the objective validity of our perceptions, the primitive is oriented to the subjective and mystic aspects of his perceptions. The dream, for example, is considered more important in primitive societies than any aspect of waking life, not because they are unable to distinguish the dreaming state from the waking state, as argued by Tylor, but because they believe that through the dream it is possible to communicate more easily with the more important and significant mystic influences that dominate their life. Similarly, explanations are not sought in physical causes, since all events are believed to occur as a result of mystic forces.

Thus he argues that it is the emphasis on the mystic properties of objects, and the failure to distinguish the mystic from the physical, that accounts for many of the characteristics of primitive thinking.

The term pre-logical is used by Levy-Bruhl to define the laws by which collective representations are connected with one another. He maintains that these connections do not follow our laws of logic. He rejects the view that they may follow some other system of logic on the grounds, first, that there is no need to assume that the connections must be logical, and second, that a concept of logic different to our definition of logic is a purely negative concept, and devoid of meaning. He argues that the connections of primitive representations are based on laws other than those we accept. For example, causality is based on mystic relations between objects which the primitive represents to himself. These mystic relations ignore objective relations and are impervious to experience.

He maintains that the essential element in primitive's connections is a participation between the persons or objects connected, and he defines the law peculiar to primitive mentality governing the formation of connections as the law of participation. This participation acts between the mystic properties of objects or beings, and has causal effects. The natural relation of cause and effect is less important than the participation of mystic properties, and is consequently often ignored.

In so far as primitive connections obey the law of participation rather than the logical laws of our system, Levy-Bruhl terms primitive thought pre-logical. He makes it clear that he does not intend to imply by pre-logical a stage in thought antecedent in time to logical thought, or thought which is anti-logical or alogical. Pre-logical is defined as meaning merely that connections obey the laws of participation first and foremost, and are indifferent to contradiction. He emphasises that these characteristics apply only to the collective representations of primitives, and that as an individual he may follow other laws. But he maintains that their mental activity is not always subject to the same laws as ours, and in so far as it deals with collective representations it obeys the law of participation.

He goes on to discuss the various aspects of primitive mental functioning such as memory, language, numeration, abstraction, generalisation, and classification, and the various customs and institutions characteristic of primitive societies, to show how all these can be understood and explained in terms of the undifferentiated, mystical, and pre-logical character of primitive thought.

Finally he outlines his theory of how the collective representations of societies develop from the most primitive to the most advanced forms. He suggests that the most primitive representations found are not, strictly speaking, representations at all. A representation implies a duality, a distinction between the object and the subject; but in the most primitive form of institutions found, such as the totem groups, the subject and object are not clearly differentiated, and there is a direct participation felt between all members of the group. He calls these collective mental <u>states</u> rather than representations, and states that at this stage, there are very few myths, symbols, or objects of worship, since the participations between the individual and his group are directly felt and expressed in the institutions and ceremonies of the group.

He relates this stage to that described by Kruijt, who distinguished two successive stages in the evolution of primitive communities, which he related to corresponding differences in the mentality of the communities. At the first stage souls and spirits are not yet individualised, and the individual consciousness of every member of the group is and remains solidary with the collective consciousness. Only later, at the second stage, does the human individual become clearly conscious of himself as an individual, and only when he explicitly differentiates himself from the group of which he is a member, does he also endow other beings and objects outside himself with individual minds or spirits.

Progress from this primitive collective mental state occurs as the relations between the social group and the individuals composing it are evolved. As the individual consciousness develops, and the existence of other individual consciouses is recognised, the group itself comes to be recognised and defined. Consequently the feeling of direct participation between all members of the group is weakened, and more specific and defined mystic relations between individuals and groups or objects are formed. The direct participation of the earliest stage is therefore replaced by intermediary mystic relations. These intermediaries take the form of myths, symbols, religious practices, and sacred objects and beings, and are found in great profusion in the collective representations of those societies at this point of development. Those particular beings or objects which serve as intermediaries then become surrounded with mystic properties, while those beings or objects not endowed with any mystic forces tend to be represented in an indifferent and impartial way, thus becoming less mystical and more objective. This results in the distinction between the sacred and the profane, leading to a distinction between the mystical and the objective, and to various changes in the collective representations of the society. Original classifications of objects and beings, based on mystic properties, tend to break down as these mystic properties become less important, and new classifications are made based on more objective properties. This in turn affects perception, which tends to become more oriented to the objective properties of objects. With this process thought becomes more differentiated, with the mystic and affective properties being separated from the physical and intellectual properties of objects and beings, and thus giving rise to true representations or ideas, enabling the formation of concepts.

This development occurs first in those areas where the original mystic properties become less important. Here contradictions come to be recognised, and the collective representations are modified. But in areas where mystic properties are still strong, contradiction is not recognised. However, the development of logical concepts and objective thinking in some areas influences individual thinking in other areas, and gradually logical thought is developed and applied to more and more of the collective representations of the group. The development of collective general concepts and individual logical thought therefore proceeds simultaneously, each reacting on the other.

Levy-Bruhl maintains that this process is not necessarily progressive, that the evolution of concepts does not necessarily proceed to the more advanced, and that the weakening of mystic elements is not inevitable and not always continuous. The mentality of any society may long remain pre-logical and mystical. He points out that abstract and general concepts may retain some elements of pre-logical and mystical thought, and that if these concepts become fixed and inflexible at an early level of development, and are not subject to modification with increasing knowledge and experience, they may act as an obstacle to progress. He suggests that this occurred in the case of scientific knowledge in China, which for many centuries made no progress although it produced a great deal of complex writing and logical argument on a variety of subjects.

He states that even where logical thought continues to progress, and reaches its highest development, as in our own society, it will never entirely supersede pre-logical thought. First, because most of our concepts will still retain some trace of their mystic and pre-logical origin, and second, because even when the intellectual and conceptual elements of objects are completely differentiated from the affective and motor elements, these latter elements yet remain and are co-existent with the intellectual elements.

Finally, he maintains that the growth of logical thought does not necessarily imply the eventual extinction of pre-logical thought. While logical thought is intolerant of contradiction and will attempt to impose its laws on all thought, there are certain collective representations which are so strongly felt and lived that they will resist the laws of logical thought, as demonstrated by the persistence of religion in our own society.

Criticisms of Levy-Bruhl's Theory

Evans-Pritchard (1934) has reviewed some of the main criticisms of Levy-Bruhl's theory. He points out that much of this criticism is based on a misunderstanding of the terms Levy-Bruhl has used. For example, the term 'pre-logical' has been understood by his critics to mean something like 'incapable of coherent thought', and they have thought that by providing examples of coherent thought in primitive peoples, they are refuting Levy-Bruhl's theory of pre-logical thought. Similarly, misunderstandings have occurred with his terms 'mystical' and 'participation', and with his use of the term 'thought'. Whereas Levy-Bruhl generally uses the term 'thought' to refer to the social content of thought, that is, the collective representations of the society, his critics have taken this term to refer to individual processes of thinking. Lowie (1937) objects to Levy-Bruhl's use of the term 'law', since he states that his 'law' of participation cannot predict or explain specific events. However, he accepts his basic thesis that irrational associations precede the analytical recognition of ideas.

Evans-Pritchard points out that most of the criticisms of Levy-Bruhl's theory are ineffective, disproving what no one holds to be proved, and seldom touching his main propositions. In fact, he maintains that many of his critics were merely repeating

Levy-Bruhl's views under the impression that they were refuting them. Other criticisms of Levy-Bruhl are based on details of his methodological procedure, the uncritical manner in which he handled his material, and his use of unreliable sources. Such criticisms similarly do not touch on the main points of his theory.

Evans-Pritchard draws attention to what he terms the 'more serious methodological deficiencies' of Levy-Bruhl's work. These deficiencies are stated as:

1. He makes savage thought far more mystical than it is.
2. He makes civilised thought far more rational than it is.
3. He treats all savage cultures as though they were uniform, and writes of civilised cultures without regard to their historical development.

These criticisms are as unfounded as the previous criticisms. It is perhaps true that in the text of his work Levy-Bruhl may appear to be guilty of these faults at times, but he makes it clear in his introduction that his aim is to compare the most primitive forms of thought found in primitive societies with the most advanced types of thought found in our society, since he believes that an examination of the most extreme forms of thought found will assist us to understand better the intermediate forms. He then proceeds to examine the collective representations of various societies to look for the most primitive forms of thought and to compare these with the intermediate and more advanced forms of thought. This procedure does not mean that he treats all primitive cultures as uniform, or that he makes primitive thought too mystical and our thought too logical. His final study of the transition from the most primitive to the most advanced types of thought makes it quite clear that this criticism is without any real foundation.

The basic criticisms of Levy-Bruhl rest on his use of the collective representations of primitive societies as a means of studying their thought processes, and his apparent tendency to confuse individual thinking ability with the thought processes that are determined by the collective representations of the society. Although he perhaps does not always make himself clear on this point, he does distinguish clearly between these two types of thought. He frequently points out that certain types of thought found when the individual is dealing with the collective representations of his society need not necessarily be found when the same individual is dealing with other practical matters which are not governed by the collective representations. This point is made particularly clear in his discussion of the transition from primitive to more advanced forms of thought. However, he does believe that the thought processes determined by the collective representations of the society do influence the thought processes of the individual. He points out that through the education and training which are an essential part of any society, the ideas and beliefs of a culture are imposed on each individual member of that culture from the time that he first learns to talk, and that this influence is inseparably bound up with natural development. Thus in our culture

> the claims of logical thought are urged, established, and then confirmed in each individual mind by the uninterrupted constraining force of his social environment, by means of language itself and of what is transmitted by language. This is a heritage of which no member of our community is deprived, and which none would ever dream of refusing. Logical discipline is thus imposed upon his mental operations with irresistible force (Levy-Bruhl [1928] p.107).

Similarly, he maintains that the primitive mode of thinking is imposed upon the mental operations of all the individuals composing the society, and therefore becomes the characteristic mode of thinking of that society.

Levy-Bruhl does not specify precisely how or to what extent the collective representations of the society will influence the thinking ability of the individual, or how individual thought processes determined by the collective representations of the society are related to other thinking processes which are not affected by the collective representations. He seems to assume an interaction between the individual thought processes and the collective representations of the society. While the collective representations of the society will influence the thought processes of the individual, individual thought processes in turn influence the collective representations of the society. Advances in individual thought processes will lead to modifications in the collective representations of the society, and these modifications will in turn influence the thought processes of the individual members of the society, leading to further advances in individual thought processes.

The common criticism that Levy-Bruhl distorts primitive thought by examining only one aspect of this thought and isolating it from other aspects of primitive life seems to be based on a failure to grasp this essential point of his theory. Evans-Pritchard, for example, points out that specialist field workers are agreed that primitive peoples are predominantly interested in their practical and social affairs, and behaviour of a mystical type is restricted to certain situations in social life, and is so linked with practical activities, that to attempt to describe it by itself deprives it of its meaning in the social and cultural situation. However, if it is understood that Levy-Bruhl assumes that the mental processes of the individual are influenced by the collective representations of his society, and that his purpose is to discover the laws that govern the collective representations in order to better understand the mental processes of the individual, this criticism falls away. It can only be upheld if it can be shown that in fact the collective representations of the society have no effect whatsoever on his individual mental processes. No attempt has been made to produce such evidence. This is perhaps because it is clearly recognised that the thought processes of the individual are influenced by the collective representations of his society. In order to determine to what extent the collective representations influence the individual thought processes, and how the laws governing the collective representations are related to the laws governing individual thought processes, it would be necessary to undertake a thorough investigation of both. Levy-Bruhl has provided a theoretical orientation by which such a study could be guided, and has made an initial study of the laws governing the collective representations. No attempt has yet been made to follow up this lead or to investigate the important and significant implications and possibilities that his theory have suggested.

Reasons for the Rejection of Levy-Bruhl's Theory

The same causes responsible for the neglect of the study of conceptual processes in other cultures also contributed to the rejection of Levy-Bruhl's theory. Margaret Mead (1962) in reference to Levy-Bruhl's work, states that it was 'repudiated by other anthropologists because of the importance, at that time, of emphasising the rationality and psychic comparability of primitive man' (Mead [1962] p.123).

The general failure to grasp Levy-Bruhl's basic ideas and terminology must also be considered as an important reason for the rejection of his work. Evans-Pritchard (1934) implies that this failure was largely his own fault, because of the confusion and complexity of his writings. This does not seem to be a sufficient reason, particularly in view of the fact that the contemporary writings and ideas of psycho-analytic theory, which were then widely accepted by anthropologists, were equally, if not more, confused and complex than those of Levy-Bruhl.

The reason for the widespread misunderstanding of Levy-Bruhl's work could be due to the fact that his standpoint and orientation was so far removed from that of his contemporaries, that they were unable to 'assimilate' his ideas to their existing views and conceptions on the nature of primitive thought. In terms of Hunt's (1961) 'match hypothesis', the gap was too wide. This same difficulty has occurred with Piaget's writings, and has similarly resulted in wide-spread criticisms and misunderstanding of many of his views, which are now only gradually being recognised and accepted.

3. Discussion of Levy-Bruhl's Theory and its Relation with Piaget's Theory

The essential parallel between the theories of Levy-Bruhl and Piaget lies in the notion of the development of thought proceeding by degrees from an undifferentiated state to a state of complete differentiation. In both theories the initial undifferentiated state is seen to arise from the failure to distinguish between the self and the external world, or between the individual and the group, and this gives rise to a failure to distinguish between the objective and physical aspects of objects and events, and the psychological or 'mystic' aspects of these objects and events. The gradual development of thought is seen in terms of the gradual separation of the objective and physical from the psychological or mystical, allowing the recognition and establishment of objective relations between objects and events, and consequently the development of a logic based on objective properties. Both emphasise that there exists for the child or the primitive a single world where objective and psychological are not clearly differentiated. Where similar characteristics are found in advanced adult thought, as in superstition and religion, the adult makes a clear distinction between the objective world and the spiritual or supernatural world, which are seen as quite separate and distinct, and governed by different laws, whereas for the child or the primitive these worlds are fused and not distinguished, and both physical and psychological, objective and spiritual, are not only co-existent, but are equally real and valid.

A second important parallel between the two theories lies in the notion of development proceeding as a result of the interaction between the individual and his environment. While Levy-Bruhl's emphasis on the way in which the collective representations are imposed and impressed on every individual member of the community would suggest an empiricist approach, his discussion of the transition from primitive to higher forms of thought implies quite clearly an interaction between the individual and his environment. Piaget puts considerable emphasis on this interaction, which is described in terms of the development of the internal structures of thought through assimilation and accommodation. The effect of the environment, now recognised as an essential factor in development, is therefore clearly recognised by both theories.

There is also a close parallel between Levy-Bruhl's conception of pre-logical thought and Piaget's conception of pre-operational thought, the main difference being that Piaget has defined pre-operational thought more precisely in the light of his investigations into what actually constitutes logical thought and how it develops in children. Levy-Bruhl's 'image-concept' is precisely the same as the pre-concept defined by Piaget. In describing the image-concept, Levy-Bruhl says:

> Again, while it cannot be denied that those who speak these languages have a concept of hand, foot, ear, etc., their concepts do not resemble ours. They have what I should call an 'image-concept', which is necessarily specialised. The hand or foot they imagine is always the hand or foot of a particular person, delineated at the same time....If an Indian were to find an arm that had fallen from an operating table, he would say 'I have found his arm'...(Levy-Bruhl [1928] pp.168-9).

He also refers to the image concepts as at once 'both general and particular' and states that they 'must be superseded by concepts which are really general and abstract' (ibid., p.176). This is exactly parallel to Piaget's definition of the pre-concept (see discussion p.11).

Piaget has adopted Levy-Bruhl's notion of participation, but has defined it more precisely (see p.12). Thus Levy-Bruhl's examples of pre-logical reasoning, following the law of participation, are parallel to Piaget's transductive reasoning, which argues from the particular to the particular, but cannot argue from the particular to the general or vice versa because of the lack of general classes. Piaget's theory of pre-conceptual reasoning can therefore be applied to Levy-Bruhl's examples of pre-logical reasoning.

These parallels are not intended to indicate that child and primitive thought is in any way identical.

This is not the case, since there are essential differences between them. In primitive societies pre-logical and mystical modes of thought are incorporated into the collective representations of the group in the form of highly systematised myths, customs and rites. These are imposed on every individual of the society, and this would encourage the persistence of pre-logical thought in all members of the group. In our society the child's pre-conceptual modes of thinking are not supported by collective representations, except in a few isolated areas which are sharply distinguished from ordinary everyday activities, and logical thinking is encouraged and imposed on the child. This would tend to distort and inhibit pre-logical and mystical thought in children, and to change its form of expression, so that it is not clearly defined or systematised, but appears only as tendencies of thought.

Piaget has been careful to avoid drawing any direct parallels between child and primitive thought. He acknowledges his debt to Levy-Bruhl, whose works he states 'have been a perpetual source of inspiration' (Piaget [1959] p.xxi). But he says:

> Child logic and the logic of primitive races are far too much alike in some respects, and far too different in others to justify us in discussing so delicate a parallel in connection with the scanty evidence with which I propose to deal. I shall therefore keep this discussion for a later date (Piaget [1959] p.xxi).

This statement was written in 1923. He has since collected a vast store of evidence on children's thinking, but he has not yet returned to a discussion of the parallel between child and primitive logic as promised here.

Levy-Bruhl's work is subject to the same criticisms and has the same limitations as Piaget's earlier studies. These criticisms arise from the verbal nature of the material that forms the basis of the study, and the difficulty of assessing this material and subjecting the theories based on it to objective test. Nevertheless, the criticisms of both Piaget and Levy-Bruhl have been largely overstated, and their critics seem to have missed the important and significant aspects of the work of both. Piaget subsequently developed more objective techniques for examining child thought, and these techniques will enable us to study the relation between the individual thought processes of primitive peoples and the collective representations of their society. Thus the techniques developed by Piaget open the way to the investigation of the basic problems posed by Levy-Bruhl's theory.

III. IMPLICATIONS OF PIAGET'S THEORY AND ITS RELATIONS TO GENERAL PROBLEMS OF PSYCHOLOGY

Piaget's early work was subjected to severe criticisms. These were based largely on a misunderstanding of what he was trying to do, and have been adequately discussed by Laurendau and Pinard (1962), Flavell (1963) and Donaldson (1963). The importance of his work is evident from the number of publications which have appeared in recent years both on the theory itself and on its relation to other areas of psychology. These include the works of Hunt (1961), Flavell (1963) and Berlyne (1965).

In the following section some of the most important implications of Piaget's work for psychological theory will be discussed.

1. The Effects of Experience on Development

Piaget's theory of development supposes an interaction between the individual and the environment, the structures of thought being built up as a result of the child's experiences through the processes of assimilation and accommodation. The environment is therefore crucial to the process of development.

Some writers have stated that Piaget regards development as entirely dependent on maturation (Lunzer [1960]). This misunderstanding seems to arise from a failure to distinguish between the effects of specific learning situations and the overall effects of interaction with the environment. Piaget sees these effects operating gradually in the child's interaction with his physical environment in his ordinary everyday activities, rather than in specific learning processes at school or in the home. His comments in Tanner and Inhelder (1960) make it quite clear that he accepts that under different environmental conditions and different cultures the ages at which his stages of development would appear may vary considerably, and that some of his stages may fail to develop.

Hunt (1961) has placed particular emphasis on this aspect of Piaget's theory. He points out that implicit in Piaget's theory is the principle that appropriate stimulation and exercise are necessary for the survival of reflexive and habitual schemas, and that the rate of development and differentiation of these schemas to form increasingly complex structures is largely a function of environmental circumstances. He states that this view is supported by all the evidence on the effects of early experience on later ability that were inspired by Hebb's theorising, and that Piaget's theory offers a more explicit and clearly formulated explanation for these effects than that of Hebb. While the question of whether environmental circumstances that alter the rate of development can affect the final level of intelligence remains unanswered, he states that there is some indication that the effects of early experience can be of considerable permanence, and suggests that Piaget's findings and techniques may well provide the means of investigating this problem more closely.

Hunt points out that Piaget's theory implies that for development to occur there must be an appropriate match between the child's present thought structures and the environmental circumstances to which he must accommodate. Where there is no relationship at all between what the child has already assimilated and the environmental circumstances, the child will be quite unaffected by these circumstances. He relates this to Hebb's finding that what is completely unfamiliar to the chimpanzee does not cause fear. If the environmental circumstances have some relationship to what the child has assimilated, but are still too different to allow the child to accommodate to them, this evokes fear, distress or negative motivation. He states that in terms of the 'discrepancy principle' in the theories of

Festinger (1957) and McClelland et al. (1953), this would correspond to discrepancies which are too large. This is illustrated with Hebb's finding that it is the 'familiar in an unfamiliar guise' that evokes fear in the chimpanzee. If the discrepancy is such that the child is able to accommodate his present structures to the new situation, this situation will evoke interest and curiosity. Finally, when present structures and environmental circumstances match perfectly, there is no accommodation and no development, and the result is stultifying boredom.

Hunt also suggests that the notion of critical periods put forward by Scott, Fredericson and Fuller (1951) can be explained in terms of this match hypothesis, in that environmental circumstances can be accommodated to when appropriate structures are present, but not when such structures are absent. While Hunt recognises that at present there is little basis for defining what is 'discrepant' from what, or 'capacity for accomodation', he suggests that Piaget's findings may indicate the types of experience which would provide the optimum match for the child's developing schemas at the various stages of his development, and he points to the importance of this principle to education.

Hunt's notion of 'match' may be related to Smedslund's (1959) suggestion that a new problem can be solved only by means of some relatively simple combination or differentiation of already existing schemata.

2. The Role of Maturation in Development

Piaget's views on the role of maturation in development are best expressed in his own words. He states:

> Although psychology has used and abused the concept of maturation at every level of development, neurology has had very little to say about the reality of this development, apart from certain changes in the first few months of life.
>
> We may assume, with all due caution, that in all probability maturation does play a part in the remarkable changes which occur about the age of 7-8 years, to take but a single example. (In our own 'civilised' societies, these changes are thrown into further relief by the beginning of primary education.)
>
> But we do not, in fact, know anything about it. In particular, we do not know any cognitive structure which can be shown to be wholly maturational in origin. We might make a number of negative statements. Thus it makes some sense to attribute the absence of certain types of behaviour (eg. the absence of hypothetico-deductive reasoning between 2 and 4 years) to deficiencies of the nervous system. But from the positive point of view, the maturation of the nervous system can do no more than create the conditions for a continual expansion of the field of possibilities. The realization of these possibilities demands not only the action of the physical environment (practice and acquired experience), but also the educational influences of a favourable social environment (Inhelder and Piaget [1964] p.5).

Piaget clearly assumes that the type of development that occurs is determined by the particular characteristics of neural structure and function, which is independent of society (Tanner and Inhelder [1960] p.8), and that this must set limits on the level of development achieved (Inhelder and Piaget [1958] p.243-4).

Hunt (1961) states that while Piaget rejects the view that either concrete or formal operations arise from the late maturation of neural connections, there is no evidence that rules out the possibility that some kind of 'stimulus induced maturation' may be involved.

He cites the work of Brattgard (1952) and Riesen (1958) which has demonstrated such stimulus induced maturation in the development of the visual system.

3. The Role of Language in Development

Piaget recognises the importance of language in development, but he emphasises that it plays only an auxiliary role, or acts as an accelerator, and that the development of concepts, and even of language itself, is dependent on the development of operational mechanisms which are independent of their verbal expression.

This view is most explicitly stated by Inhelder and Piaget (1964) in their latest work. It is supported with reference to the parallel development of seriation and classification in deaf and in normal children, the first verbal patterns of children at the pre-conceptual level, and the operational patterns found in the everyday use of language.

They point out that the work of Oléron (1956),[1] Vincent (1951, 1956, 1957)[1] and Affolter (unpublished)[1] and deaf children indicates that the development of seriation is not noticeably different in the deaf, and

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[1] Cited by Inhelder and Piaget (1964).

that deaf children can carry out the same elementary classifications as normal children. However, it has been found that deaf children are retarded in handling more complex classifications, and they believe that this suggests that language may be a necessary but not a sufficient condition for the completion of operational structures in their generalised form. They point out that although classification is more closely associated with verbal structures than seriation, these operations develop at the same time, and in fact development in seriation tends to precede that of classification. They believe that this illustrates conclusively that the development of these operations is independent of language.

They refer to Piaget's earlier work (1951), where he has shown that the use of a particular word by a child does not necessarily mean that a child understands the word in the same way as the adult. For example, the fact that a child calls a cat a cat does not prove that he understands the 'class' of cats.

Finally, they refer to their present study on the use of the words 'some' and 'all'. From this they conclude:

> the fact that the language of adults crystallizes an operational schema does not mean that the operation is assimilated along with the linguistic forms. Before children can understand the implicit operation and apply it, they must carry out a structurization, or even a number of successive re-structurizations. These depend on logical mechanisms. They are not passively transmitted by language. They demand an active construction on the part of the subject (Inhelder and Piaget [1964] p.4).

Vygotsky (1962), and following him the Russian school represented by Luria (1961), have put far more emphasis on the importance of language in the development of thought. However, they are in agreement with Piaget in that they see the relation between language and thought in terms of an interaction in which thought plays an active and essential part. Vygotsky (1962) stresses the importance of recognising that word meanings are not static but change with the development of the child. He believes that further progress in the understanding of the relation between language and thought must depend on this recognition.

> The discovery that word meanings evolve leads the study of thought and speech out of a blind alley. Word meanings are dynamic rather than static formations. They change as the child develops; they change also with the various ways in which thought functions[1] (Vygotsky [1962] p.124)

Vygotsky goes on to say: 'The relation of thought to word is not a thing but a process, a continual movement back and forth from thought to word and from word to thought' (ibid., p.125). From this it is clear that Vygotsky does not regard the relation between language and thought in terms of a one-sided action of language on thought, but as a complex interaction between the two.

The present work being carried out in Russia emphasises the role of speech in the regulation of behaviour. Luria (1961) refers to the speech system as 'a powerful means of systematic organisation of our

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1 My underlining.

mental processes' (Luria [1961] p.97). This relationship is seen in terms of an interaction between speech and mental processes, and it is emphasised that this is not a sudden or an immediate process, but only occurs after a long period of development and after passing through a series of stages determined by the type of mental activity and the complexity of the functional formations that are involved.

Thus while there is a difference between Piaget and the Russian school on the importance that is placed on the role of language in development, there is an essential agreement between them on the form of the relationship between language and thought, and on the active role of thought itself in this relationship.

The linguistic determinism based on the views of Whorf (Carroll [1956]) is completely opposed to the views of Piaget and the Russian school in that it ignores the active part that thought itself plays in the relationship, and regards language as the dominating and determining factor and thought as completely passive.

This view has had a considerable influence in anthropology, where the tendency has been to explain differences in the thought processes and concepts of different cultures in terms of differences in language.

Levy-Bruhl (1928) takes the view that language will reflect the particular mental habits or mentality of a culture, although he does not attempt to draw an exact correspondence between language and mental development. At the same time, he recognises that language may influence the thinking of the child. He therefore sees the relationship between language and thought in terms of an interaction, as does Piaget.

A recent approach, sometimes referred to as ethnoscience (Sturtevant [1964]), has developed methods of analysing the linguistic systems and classifications of different cultures, using the methods of descriptive linguistics. This analysis is seen as a means of arriving at an understanding of the cognitive processes and the relations between language and thought in the different cultures. The weakness of this approach is that it fails to recognise the independence of language and thought, and allows no study of the interaction between them. Brown (1964) has summarised the difference between Piaget's approach and that of ethnoscience as follows:

> For ethnoscience the mind seems to be a categorical grid imposed on reality, rendering some things equivalent and others non-equivalent. Since the cells of the grid are usually named, the design of the grid should be discoverable from inquiries about the meanings of words. For Piaget, intelligence is an activity; to think is to operate (Brown [1964] p.231).

Brown suggests that the grid conception of mind is insufficient, and that ethnoscience must come to recognise the active aspect of thought.

The recent increase of interest in problems of language and language development is reflected in the growing literature in psycholinguistics and related fields. Most of this work is not directly relevant to the problem of the relation between language and conceptual development as studied by Piaget. Nevertheless, research in this field will presumably lead to findings which have implications for his theory. In particular, Chomsky's (1957) view that language development depends on certain innate capacities has particular relevance to any theory of intellectual development, and this theory has stimulated research into language development in children.

The precise relationship between language and thought remains to be established. The influence of language on conceptual development may well be greater than Piaget has supposed. An attempt to tie up Piaget's findings with those of the Russian school should prove an extremely fruitful area of research, while the work of Chomsky could provide a basis for the study of the development of language and its relation to thought. Piaget's findings and theory on conceptual development will provide an important basis for further research into this problem.

4. The Invariant Order of the Stages of Development

The importance of the invariance of Piaget's stages of development for the assessment of intellectual development has been pointed out by a number of writers.

Inhelder (Tanner and Inhelder [1956]) has pointed out that in the Geneva tests, unlike the traditional intelligence tests, the appearance of a particular structure allows generalisation from one particular piece of behaviour to others of the same type. She suggests (Inhelder [1964]) that the Geneva method may give a truer picture of the child's thought than standardised tests, which often run the risk of missing unexpected and essential aspects of this thought.

Flavell has also pointed to the importance of basing psychometric studies on a cognitive-developmental theory, rather than having psychometrics as a 'mindlessly empiricistic, utterly pragmatic discipline' (Flavell [1963] p.417). He suggests that tests based on a developmental theory may well be a better predictor not only of convential criteria such as academic achievement, but also of ultimately more important criteria such as intellectual capabilities of an inventive and creative nature.

The recognition of the importance of Piaget's tests for the construction of a more precise scale of mental development than that offered by traditional intelligence tests has led Pinard to undertake a systematic replication for the purpose of constructing such a scale.

A number of writers, including Hunt (1961), Flavell (1963) and Wohlwill (1960), have suggested the Guttman scale technique as a method of establishing the invariant order of Piaget's stages. Hunt (1961) has pointed to the importance of such a scale for developmental studies and for studies on the effects of different types of environment and experiences on development. He suggests that the order of the stages of development should be verified in conditions where exceptions are most likely to be found, such as under widely differing cultural environments, widely differing experiential environments (for example, the orphanages described by Dennis [1960] in the Near East), and in mentally sub-normal and schizophrenic individuals.

Inhelder (1944) has substantiated the invariant order of development of conservation of quantity, weight and volume in the feeble-minded. Woodward (1959) has confirmed the order of development of Piaget's sensori-motor stages in the behaviour of idiots, and has found a correspondence between their general level of sensori-motor development and the development of the object concept. She has also studied the development of the concept of number in sub-normal children and adults (Woodward [1961]). She found that their responses could be classified in terms of Piaget's stages, but that there was not a clear correlation between performance on Piaget's tests and I.Q. scores. She suggests that a direct study of number concepts by means of Piaget's tests is a more useful method of estimating a sub-normal person's readiness to deal with number than an intelligence test score.

These findings offer support to the invariance of Piaget's stages and the greater value of being able to determine the actual level of mental development as against an intelligence test score based on the summation of responses on a wide variety of tasks.

Freeman and McGie (1956) have described schizophrenic behaviour in terms of Piaget's stages of sensori-motor development. They relate the generally accepted view that schizophrenia involves a lack of differentiation between the self and the external world to the same characteristic that Piaget has described in the infant. They suggest that the habitual repetitive movements often observed in schizophrenia may correspond to Piaget's circular reactions, and that echopraxia may be an early form of imitative accommodation. They therefore suggest that the symptons of schizophrenia may be caused by the disintegration of adult structures of thought, and that there is no need to attempt to explain these symptoms in terms of complex psychological processes.

Monnier (Tanner and Inhelder [1960] p.133-5) has offered some support for Piaget's stages with his findings on E.E.G. changes with age. He has found clear patterns of E.E.G. activity at certain ages, with a constant order of succession for these patterns, marked by progressive differentiation, systematisation and localization of the cerebral electrical activities. He also finds a discontinuity between the stages which mark a preparation for the following stage. Once a pattern has been acquired, it will not regress to the previous stage. Some of these changes in E.E.G. activity occur at the same ages that Piaget has given for the achievement of various stages of development. For example, Monnier finds that the first major change in the E.E.G. pattern occurs at six to seven years, another change occurs at about nine years, and a further change occurs at about eleven years. These changes show a remarkable correspondence to the stages postulated by Piaget.

Piaget and Inhelder (Tanner and Inhelder [1960]) have made it clear that the age at which the stages are achieved can vary both according to the individual's experience and his heredity potential, but that the order of the succession of stages must be constant. This order is regarded as a fixed feature of the organism environment interaction.

5. Individual Differences in Intelligence

It has been pointed out by Hunt (1961), Flavell (1963) and others that Piaget's theory does not account for individual differences in intelligence, since all children at a certain age level will possess the same basic set of operations.

One reason why Piaget's problems do not reveal individual differences in intelligence may be because his tests do not measure the speed with which the child is able to solve a particular problem. Time limits are an essential feature of intelligence tests, and Eysenck (1953) has pointed out that individual differences in intelligence are in fact measured mainly in terms of the speed with which an individual is able to solve a set of problems.

This raises the question as to how Piaget's stages of development are related to individual differences in intelligence.

A possible suggestion is that individual differences in intelligence may determine the rate at which a child is able to progress from one stage of development to the next.

This rate of development could involve two factors -

1. The amount of experience a child requires in order to go from one level to the next.

2. The degree of difference between the old and the new to which he can adapt.

(That is, the degree of discrepancy between the environmental circumstances and his present structures which he is able to accommodate to).

These factors would be determined by neural properties, thus corresponding to Hebb's Intelligence A, which is genetically determined.

This view would seem to be consistent with common-sense observations - that is, a bright child is able to progress quicker with fewer experiences or demonstrations and is able to make a bigger jump from one step in a problem to the next.

It is also consistent with Bartlett's (1958) suggestion that intelligence may be defined in terms of the degree to which an individual can utilise the minimum amount of information given or can overcome gaps in the given information.

According to this view the intellectual potential of the individual would determine how much experience he requires to reach a solution to a problem and how readily he can adapt to increasingly different or unfamiliar situations.

If Piaget's techniques can be modified to measure these factors, it is possible that they may be able to provide not only a measure of the stage of development actually reached, but also a measure of individual differences in intellectual potential. This has been suggested by Inhelder (Tanner and Inhelder [1956] p.91), and is in agreement with Vygotsky's suggestion that a child's zone of potential or 'proximal' development should be measured by assessing how far a child is able to progress given some assistance. Vygotsky suggests that such an assessment would be of greater value than a mental age score. Luria (1961) has pointed out that such a dynamic investigation of potential ability could lead to considerable changes in methods of the practical assessment of intelligence.

Flavell (1963) has suggested that individual differences in intelligence may also be related to the stability and generalisability of the final stage strategy and the accessibility of the earlier stages under regression inducing conditions. These factors would determine resistence to suggestion or apparent contraction.

6. Relation to Factor-Analytic Studies

Hunt (1961) raises the problem of the apparent contradictions between the findings of factor analytic studies and Piaget's findings on intellectual development. However, he points out that recent interpretations of factor studies in terms of a hierarchical structure of abilities, such as that of Ferguson (1954, 1956), are in fact quite consonant with Piaget's view of intelligence. He also refers to the study of Hofstaetter (1954) which gives strong support to Piaget's stages of development.

7. Piaget and Hebb

Hunt (1961) also draws a number of parallels between Piaget's theory and that of Hebb, both of which involve a gradual development from simple to complex neural structures as a result of past experiences in interaction with the environment. He points to the similarities between these conceptions of intelligence and those deriving from the work of Newell Shaw and Simon (1958) on information processing strategies, Harlow's (1949) work on learning sets in monkeys, and recent neuro-physiological evidence. He maintains that all these theories lead to a conception of intelligence as 'problem solving capacity based on a hierarchical organisation of symbolic representations and information-processing strategies deriving to a considerable degree from past experience' (Hunt [1961] p.109).

CHAPTER II

THE THEORETICAL BASIS OF PIAGET'S TESTS ON CONSERVATION

In this chapter Piaget's studies on conservation which form the basis for the tests used in the present study will be described, and his theory of the development of conservation will be outlined. No attempt will be made to evaluate this theory in the present section.

This chapter will be divided into the following sections:

1. General outline of the concrete operational structures on which conservation is based.
2. Conservation of Quantity.
3. Conservation of Substance, Weight and Volume.
4. Conservation of Number.
5. Conservation of Length and Area.
   - A. Length
   - B. Area.
6. Discussion of apparent inconsistencies in Piaget's theory of the development of conservation.

1. General Outline of Concrete Operational Structures

According to Piaget conservation depends on the development of concrete operational structures. He distinguishes two types of operations; I, logical (logico-arithmetical) operations, and II, physical (infra-logical or sub-logical) operations.

I. Logical operations are defined as those operations applied to sets of discrete objects or units related according to the qualities of their elements.

These qualities may be related by symmetrical relations of resemblance, or by asymmetrical relations of difference. This results in two separate systems of operations.

1. Operations applied to sets related by symmetrical relations of resemblance, which give rise to the logic of classes based on operations of addition and subtraction of classes and relations of class inclusion.
2. Operations applied to sets defined by asymmetrical relations of difference, which give rise to the system of logic applied to seriable qualitative differences.

The fusion of these two systems of logic gives rise to the notion of the unit. This is best illustrated in the case of number, which depends on the understanding that an element can be at the same time both equivalent and non-equivalent. That is, it is at the same time both a member of a class of symmetrical relations (equivalent), and a member of a class of asymmetrical relations (non-equivalent). It is equivalent in that elements can be added to form classes irrespective of their qualities, and non-equivalent in that each element remains distinct from the point of view of order and can therefore be seriated (or counted).

The notion of the unit achieved by the fusion of these two systems of operations is said by Piaget to be essential for the achievement of conservation and quantification.

II. Physical operations are defined as those operations applied to the spatio-temporal relations of the object itself. These relations are of two types, and give rise to two systems of operations corresponding to those described in the case of logical operations. These are:

1. Relations of proximity, which correspond to the symmetrical relations of resemblance, and give rise to operations of sub-division applied to part-whole relationships.
2. Relations of difference or changes of order and position, which correspond to the asymmetrical relations of difference, and give rise to operations of order and change of position.

The fusion of the operations of sub-division and order and change of position similarly give rise to the concept of the unit, which in the case of physical operations results in measurement and not in number. The essential difference between logical and physical operations is that logical operations result in concepts of number or of discrete wholes and discontinuous classes, which are independent of space and time, while physical operations result in the formation of continuous unitary wholes placed in time and space.

Piaget points out that physical operations involve the creation of an invariant object as such, or the creation of a unified and continuous spatial or temporal whole, while logical operations involve the linking together of the invariant objects or units of matter created by physical operations, and arranging them in sets of classes or numerical collections which are independent of space and time.

These two types of operatins are indistinguishable in propositional form, and correspond term for term, physical operations being merely a particular species of logical operations, the only difference being that logical operations result in discontinuity and physical operations in continuity.

These two types of operations are interdependent and develop synchronously, because both are dependent on reversibility.

The notion of reversibility is fundamental to Piaget's theory of the development of thought.

Reversibility is defined by Piaget as 'the permanent possibility of returning to the starting point of the operation in question' (Inhelder and Piaget [1958] p.272). Reversibility therefore implies that every operation can be cancelled by an inverse operation. It is only with the achievement of reversibility that the operations applied to sets can be combined into systems of operations or groupings which are in equilibrium in that every operation can be cancelled by an inverse operation. By means of these systems the child is able to combine static situations and transformations into a single system such that every situation is seen to be the result of a particular transformation, and for any transformation there is an inverse transformation which results in a logically necessary return to the initial state. Only when operations are combined in such a reversible system is the child finally able to co-ordinate all perceptual relationships and to be independent of the immediate perceptual situation. Thus the development, co-ordination and synthesis of the systems of logical and physical operations just described depends on the gradual development of reversibility.

Piaget notes three particular characteristics of the development of thought:

1. The development from the primacy of perception to the primacy of deduction.
2. The progressive co-ordination of operations.
3. The gradual development of reversibility.

He describes these characteristics as 'three aspects of a single process that defines the evolution or reason' (Piaget [1952] p.202), and the conservation of quantity, weight, volume, length, area and number is explained in terms of these three aspects of the development of thought.

2. Conservation of Quantity

Piaget (1952) believes that the notion of quantity has its origin with the recognition of qualities and the perceptual relationships between qualities. These relationships may be of two types:

1. The recognition of similarities which give rise to classifications. (Symmetrical relations of resemblance).
2. The recognition of the gross differences 'more' or 'less', which give rise to seriations. (Asymmetrical relations of difference).

He maintains that the recognition of differences between qualities always implies quantity, and that primitive quantification is found at the same time as the recognition of qualities.

In his work on number (Piaget [1952] Chapter I), he studies the conservation of continuous quantity in a situation where equal amounts of liquid are poured into identical standard glasses. Once the child has agreed that the amounts are equal, the liquid from one glass is poured into a different shaped glass, e.g., a tall narrow glass or a short wide glass, or is poured into a number of smaller glasses, and the child is asked if the amount of liquid in the new glass or glasses is equal to that in the standard glass.

The development of conservation in this case depends on the parallel development of operations applied to similarities and operations applied to differences, which are finally co-ordinated and fused.

The operations applied to similarities are those of class-inclusion, which give rise to the understanding that the part is included in the whole, that the sum of the parts is equal to the whole, and that each part is equal to the whole minus the remaining parts.

The operations applied to differences are those of logical multiplication, which enable the child to take account of several differences simultaneously, and so to co-ordinate asymmetrical relations of difference.

Piaget distinguishes between 'intensive' and 'extensive' seriation. Intensive seriation is based on logical multiplication only, and is insufficient to ensure conservation, since discrimminations of more, less or equal can be made in certain situations only; i.e., when all the perceptual relationships are equal, when only one perceptual relationship varies, or when the perceptual relationships vary in the same direction. When the perceptual relationships vary in opposite directions logical multiplication is insufficient to determine whether the quantities are equal, or which quantity is greater.

Extensive seriation depends on the fusion of class operations and logical multiplication, resulting in the notion of the unit and extensive quantification. It is this fusion that enables the child to understand that what the quantity loses in one dimension it makes up in the other, since the whole is composed of homogeneous parts or units which remain constant whatever their distribution. This is what Piaget terms 'equating the differences', and it is this achievement which he claims is the basis of conservation of quantity.

The following stages of development are described for the conservation of continuous quantities.

Stage I

At the first stage quantity is judged on the basis of immediately perceived perceptual relationships only. Since these are not co-ordinated, the child's judgement is based on only one relationship at a time, that on which his attention is immediately focused. This gives rise to contradictions in his judgements. For example, at one moment he may focus on the level of water and judge that one glass has more because the level is higher, but at the next moment he may focus on the width of the glass and judge that the other glass has more water because it is wider. The child is unable to resolve these contradictions since he is unable to co-ordinate the relationships in order to take account of two relationships simultaneously (logical multiplication). The child is also unable to compose part-whole relationships, since when the liquid is divided into several small glasses he judges either that the small glasses contain more liquid because there are more glasses, or that the small glasses contain less liquid because there is less in each glass compared with that in the standard.

Thus at this level there are neither operations of partition nor of logical multiplication, and each judgement is independent and is unco-ordinated with other judgements.

Stage II

At this stage intermediate reactions are found, the children accepting conservation in some cases but not in others. These reactions indicate the child's first attempts to co-ordinate the perceptual relationships and to transform them into true operational relations.

The first attempts at logical multiplication are found when the child succeeds in co-ordinating the relationships of width and level when the levels are made equal, but not when the levels are unequal, or when the child succeeds in conservation when the differences in level and width are slight, but not when these differences are more marked.

The first understanding of partition occurs when the child understands that the parts remain equal to the whole when it is divided into two parts, but not when it is divided into three or four parts.

These first attempts at co-ordination are not successful, since they are not based on a system of reversible operations, and therefore break down as soon as the perceptual illusion of a greater or less quantity becomes too strong.

Stage III

At this stage children show immediate conservation. This conservation is based on the fusion of the operations of logical multiplication and those of partition. The logical multiplication of perceptual relationships enables the child to take account of perceptual differences simultaneously, and so to co-ordinate these differences. The operations of partition enable the child to conceive of the whole as divisible into parts whose sum is equal to the whole. The fusion of these operations, resulting in the notion of the unit, enables the child to understand that the differences between the perceptual relationships can compensate one another (equating of differences). The notion of the unit is the basis of conservation, since with this notion the child is able to conceive of a quantity as divisible into an infinite number of units, and a transformation as simply a redistribution of these units, the units remaining constant regardless of changes of form.

The development of intelligence through each of these stages is explained in terms of the reversibility of the child's thought.

At the first stage, the child's thought is completely irreversible. Each perception is successive and cannot be combined with any preceding perceptions. This is because they are not combined into systems which are in equilibrium in that every operation can be cancelled by an inverse operation. It is because of this irreversibility that the child is unable to co-ordinate the perceptual relationships.

At the second stage there is the beginning of reversibility, which enables the child to co-ordinate the perceptual relationships in some cases. However this reversibility is not yet generalised to all situations.

At the third stage complete reversibility is reached and thought becomes independent of the perceptual situation.

3. Conservation of Substance, Weight, and Volume

In their study of the development of physical quantities, Piaget and Inhelder (1962) study the development of the conservation of substance, weight and volume in the case of a plasticine ball which is subjected to various transformations. For each transformation the child is questioned as to whether there is now the same amount of plasticine as before, whether the plasticine is the same weight as before, and whether it is the same size (volume). In each case the transformed plasticine is compared with a ball identical to the original ball, which had been agreed to be the same amount, weight, and size as the original. Weight was demonstrated by means of a balance, and volume by displacement in water, and in each case the questioning referred to these practical demonstrations of weight and volume. For example, the child was asked if the two pieces of plasticine were placed on the scale, would the scale balance or would one piece make the scale go down; or he was asked if the two pieces were placed in glasses containing the same amount of water, would the water in the two glasses rise to the same level, or would the water in one glass rise to a higher level.

They found that the conservation of each of these quantities followed precisely the same stages of development, and was dependent on the same operational structures, but that there was a difference in the age at which these conservations were achieved; conservation of substance was achieved at about seven to eight years, conservation of weight at about ten years, and conservation of volume from about twelve years. This they term a 'horizontal decalage'.

The operational structures on which these conservations depend are said to be precisely the same as those described in the case of continuous quantity. That is, the parallel development of operations applied to symmetrical relations of resemblance (i.e., class operations of the relation of parts to whole), and asymmetrical relations of difference (i.e., logical multiplication of relations of difference leading to intensive seriation), and the fusion of these two sets of operations by the equating of differences, giving rise to the notion of the unit. The stages in the development of conservation of substance, weight and volume are also precisely the same as those described in the case of continuous quantity. These are:

1. An initial stage of non-conservation, where the child is unable to apply part-whole operations or to co-ordinate relations of difference, and consequently makes his judgements on the basis of only one perceptual relationship at a time (e.g., it's heavier because it's flat, or it's bigger because it's long, etc.).

2. A transitional stage during which the child is able to apply part-whole relationships or to co-ordinate relations of difference in some cases, but is not able to generalise these operations to cover all situations. Thus the child may recognise conservation in some cases but not in all cases.

3. A final stage of conservation, where the child immediately understands conservation as logically necessary, since he understands that any change in form involves only a redistribution of the units of which the object is composed, these units initially being granted only invariance of substance, later being granted invariance of weight, and finally invariance of volume.

Piaget and Inhelder distinguish the following stages in the development of physical quantities.

Stage I

Non-conservation of substance, weight and volume.

Stage II

A. Intermediate reactions for conservation of substance.

B. Conservation of substance, with non-conservation of weight and volume.

Stage III

A. Intermediate reactions for conservation of weight.

B. Conservation of substance and weight, with non-conservation of volume.

Stage IV

A. Intermediate reactions for conservation of volume.

B. Conservation of substance, weight and volume.

Stage I and Stage II A and B correspond to Stages I, II, and III in the case of conservation of continuous quantities. Piaget and Inhelder note a slight decalage between these corresponding stages, conservation of continuous quantity being achieved at about six to seven years, while conservation of substance in the plasticine ball situation is achieved at about seven to eight years. (It should be noted that the terms 'quantity' and 'substance' are synonomous. For convenience and to distinguish between Piaget's tests of conservation of quantity in the case of the glasses of liquid and the plasticine balls, the term quantity is used with reference to the first situation and the term substance with reference to the second situation. This corresponds with the terminology used by Piaget in these two tests.)

Conservation is usually justified by reference to:

1. Compensation.
2. Reversibility.
3. Identity.

Compensation clearly refers to the equating of differences. For example, the child will say 'it's long but it's thin' i.e., what it loses in one dimension it makes up in another.

Reversibility refers to the possibility of returning to the initial state, with the clear implication that this necessarily implies conservation e.g., 'It's the same because if you put it back into a ball it will be the same again'.

Explanations referring to identity seem to depend on a simple identification e.g., 'It's the same because it was the same before' or 'It's the same plasticine,'. However, Piaget and Inhelder reject the view that in these cases conservation is based on identification as such, since they point out that children showing non-conservation also know perfectly well that it is exactly the same placticine that has been changed from a ball into a sausage or a flat cake, or has been broken up into pieces. Identification is therefore not in itself sufficient to ensure conservation. They point out that recognition of identity cannot be based on immediate perception, since in fact the immediate perception is different to the initial perception. They therefore maintain that the recognition of identity can only be based on a system of operations linking the initial form to the present form by means of a series of transformations, and that such a system implies operational reversibility.

Piaget and Inhelder distinguish between an empirical return to the starting point and true reversibility based on operational transformations. They point out than an empirical return to the starting point does not necessarily ensure conservation, since it is not based on a system of inverse operations and transformations as in the case of true conservation based on reversibility.

Since Piaget and Inhelder find that conservation of substance, weight and volume depend on the same operational mechanism, it is necessary for them to explain why these conservations are not found simultaneously; that is, why the operations applied to quantity are not at the same time applied to weight and to volume.

They explain this in terms of the gradual differentiation of the qualities of substance, weight and volume from an initial undifferentiated global quantity, and the greater difficulty of detaching notions of weight and volume from the subject's own activity (ego-centrism) and his immediate perceptions (phenomenism).

Stage I

At the first stage neither substance, weight nor volume are conserved, and non-conservation of any one of these qualities may be attributed to the non-conservation of any of the other qualities. For example, the child may say that it's more because it's big, or it's big because it's heavy. At this initial stage qualities are not differentiated and are associated together in a global concept of quantity.

Stage II

Piaget and Inhelder compare the conservation of quantity with the conservation of the perceptual object as such, and point out that with the actual deformation of the object what is conserved is no longer the total perceptual object, but the sum of the elements which constitute the object.

They state that the appearance of conservation of substance marks the differentiation of substance as a sort of support or common quality which is conserved despite changes in form of the object. They note that the concept of substance appears at the same time as conservation of substance. The one does not precede the other, and substance is only recognised as a separate and independent concept when it becomes subject to composition, quantification, and conservation. At this level substance is differentiated from and becomes independent of weight and volume, which remain undifferentiated and global and are not yet subject to synthesis and composition, and cannot therefore be quantified or conserved.

Stage III

The concept of weight develops later than that of substance because it is at first assimilated to the child's own sensory impression of weight. For example, the ball is judged to be heavier because it _feels_ heavier in the hand since the weight is concentrated in one part. Invariance of weight is therefore not attributed to the homogeneous parts of substance since a redistribution of parts results in a difference in the sensory impression of weight. The concept of weight therefore remains ego-centric and tied to the child's own activity and tactile-muscular impressions. The children's explanations indicate that weight is conceived as a force which is not homogeneous and proportional to its mass, but depends on the particular form or concentration of its elements. For example, the ball may be judged to be heavier because it is 'tight', while the pieces are said to be lighter because they are 'loose'. Alternatively, judgements may be made according to the amount of matter in contact with the balance. For example, the flattened piece may be judged heavier because there is more plasticine touching the balance, while the ball is judged lighter because only a small part of the plasticine touches the balance.

All these judgements are subject to contradictions, since with increasing change in form the children tend to change their criteria, or they will employ conflicting criteria. For example, a child may first state that the long piece is heavier because it is stretched, but at the next moment he will state that it is lighter because it is loose.

Piaget and Inhelder also found that weight was not conserved with a change of position. If two identical long pieces were judged to be the same weight, and one was then turned 90^{o} so that one piece was placed horizontally and the other vertically, the vertical piece was usually judged to be lighter, the child comparing only the width of the vertical piece with the length of the horizontal piece. Non-conservation of weight was also found with movement. If two identical balls were judged to be equal, and one ball was then rotated on a string, the children usually judged that the ball which moved was heavier, apparently because it was believed in some way to have assimilated to its weight the force that was used to turn it. Alternatively, the moved ball might be judged to be lighter, because it is supported or held up by the string.

Weight is therefore not yet differentiated as an objective quantity but is confused with notions of mass, concentration, and force, and is assimilated to the child's subjective and tactile-muscular impressions of weight rather than to a grouping of independent and objective relations. Conservation of weight therefore depends on decentration from subjective notions of weight and the attachment of weight to the object itself, so that weight can become objective and can be incorporated into an operational grouping of relations. This process follows the same development as in the case of substance, with the gradual composition and co-ordination of relations of weight as these are detached from subjective impressions and become objective, and invariance of weight is attached to the units of matter or substance. It is facilitated by the prior construction of the operational grouping in the case of substance, since the new operations relating to weight are inserted into the group of operations already established for the object.

Stage IV

Just as the recognition of homogeneous parts is not in itself sufficient to ensure conservation of weight, this recognition is also not sufficient to ensure conservation of volume, since volume is at first believed to vary according to the compression or decompression of the elements of matter. Conservation of volume therefore requires one further co-ordination, that between quantity of matter and the concentration of elements. To achieve conservation of volume the child must understand that the units of matter neither dilate nor compress in the course of transformation.

It is this understanding which is still lacking at Stage III B, where the children show conservation of substance and weight but do not conserve volume. At this stage the children may judge volume according to whether the object is 'round', 'spread out', 'in little pieces', 'loose', 'all together' and so on. These judgements are made because the child believes that the quantity of matter may be compressed or dilated during transformation, and that the parts therefore do not maintain a constant volume. They are therefore reduced to judging volume according to perceptual relationships, just as they had done previously in the case of substance and weight, and since their criteria are not objective they are constantly changing, and the child may oscillate between two judgements or give contradictory answers according to the particular aspect of the situation on which he focuses attention.

Conservation of volume is finally achieved at Stage IV B, and depends on both an atomistic schema and the elaboration of relations of concentration and of density. In a later work Inhelder and Piaget (1958) point out that the concept of volume presupposes the ability to handle proportions, which is only achieved at the formal level of thought which is reached at about 12 years. Once these schemas have been achieved volume can become differentiated as an objective quality subject to quantification, whose relations can be composed and co-ordinated by logical operations, and inserted into operational groupings which are then co-ordinated with the groupings relevant to substance and weight. The final achievement of conservation of volume therefore follows the same process of composition and co-ordination of relations as seen in the case of substance and weight, and when conservation of volume is finally achieved it is justified by reference to conservation of substance and weight, since these three qualities are again seen to be interdependent such that conservation of each one implies conservation of each of the others.

4. Conservation of Number

Piaget first studied conservation of number in a situation where rows of objects were placed in one-one correspondence, and the correspondence was then broken down by lengthening or shortening one row, or changing one row into a heap, and the child questioned as to the equality of the two sets of objects. Two types of one-one correspondence were studied; that in which complementary objects were placed in one-one correspondence (e.g., eggs and egg-cups), and that in which identical objects were placed in one-one correspondence (e.g., counters or sweets).

He found that conservation of number in this situation followed precisely the same stages of development as in the case of conservation of continuous quantities, and depended on the development of the same logical operations. Conservation was finally achieved at Stage III, at about six to seven years. Later work in Geneva has indicated that conservation of number may depend on the number of elements involved in the situation, and that conservation of larger numbers (20 to 30) may be achieved at a later age than the conservation of the small numbers (six or seven) used in this particular situation. This phenomenon Piaget has termed 'progressive arithmetisation' (Piaget [1960]).

Conservation of number was also found at about seven years in the test which he used to study conservation of volume (Piaget, Inhelder and Szeminska [1960] ch.XIV). In this test the child was required to build a number of unit blocks into a block of exactly the same volume as that of a given block, but constructed on a base of a different size. The child was also asked to compare the volumes of different shaped blocks, and to judge whether or not they would displace the same amount of water. This test therefore parallels that of conservation of the volume of the ball of plasticine. In this test Piaget was particularly concerned with the measurement of volume. However, he found that the conservation of the actual number of unit blocks was achieved at precisely the same stage of development as conservation of number and quantity, as established in his previous studies, that is, at Stage III, at about six to seven years. He states that this conservation depends on precisely the same operations as conservation of quantity, i.e., operations of logical multiplication and class inclusion. He distinguishes conservation of number in this case from conservation of interior volume, which depends on the co-ordination of the infra-logical operations of sub-division and change of position, and conservation of occupied volume, which depends on the synthesis of these operations.

5. Conservation of Length and Area

Piaget's study of length and area forms a part of his work on the development of geometrical concepts (Piaget, Inhelder and Szeminska [1960]), which is a continuation of his study of the development of spatial concepts (Piaget and Inhelder [1956]). In the latter work Piaget and Inhelder found that topological notions of space are developed before projective and Euclidian notions, which develop synchronously at a later level and are finally achieved at the stage of concrete operations. The work on geometrical concepts studies in more detail the development of Euclidian concepts of space, and particularly the development of measurement.

Piaget regards conservation as basic to the development of Euclidian concepts and measurement. He points out that topological and projective notions are not sufficient to bring about conservation of spatial objects (length, area, distance); the conservation of wholes as in topological nesting series not implying conservation of the spatial object.

He argues that the conservation and measurement of spatial objects depends on the development of physical or infra-logical operations, which parallel the logical operations determining conservation of class and number (see pp.65-8).

A. Conservation of Length

Piaget distinguishes between filled space (length) and empty space (distance). He maintains that initially the child considers length and distance as independent, and is unable to relate or to co-ordinate them into a common spatial framework. This results in non-conservation of both length and distance. When the child is able to co-ordinate length and distance and to recognise that solid objects occupy sites which remain constant regardless of whether they are empty or filled, he is able to conceive of space as a container or system of reference which is independent of its particular content. It is this recognition that enables the child to understand conservation of length and distance.

This is achieved by the development of two sets of operations, which are initially independent but are gradually co-ordinated and finally synthesised. These operational groupings are:

1. <u>Operations of order and change of position</u>

These determine the asymmetrical relations between points on a line, i.e., A precedes B, B precedes C, and the order ABC, or its inverse CBA, remains invariant.

Initially a change of position is seen only as a change in the end point, i.e., in positional order, since the child fails to take account of the interval between the starting point and the end point. In order to achieve an operational concept of change of position, it is necessary to relate the change of position to a system of fixed sites, i.e., a co-ordinated reference system, such that an object or a path of movement is seen in terms of an ordered system of points and intervals.

2. <u>Operations of sub-division</u>

These determine the symmetrical relations constituted by the intervals between ordered points, which form an enclosing or nesting series (i.e., part-whole relationships). These intervals may apply to empty or filled sites. To achieve operational sub-division, these intervals must be related to a system of fixed sites, which ensures conservation of the interval.

The achievement of these two groupings are interdependent, since the achievement of operational change of position depends on recognition of the interval between two points, while the recognition of invariant intervals is dependent on the ordering of the asymmetrical relations from which the interval relations are extracted. Conservation of length therefore depends on the co-ordination of operations of change of position and sub-division, such that these two groupings are simultaneously applied, and these two groupings in turn depend on the co-ordination of empty and filled spaces which enables the recognition of a common spatial medium which can be used to establish fixed reference points.

Piaget maintains that operations of measurement depend on the synthesis of these two groupings which results in the recognition of the unit and consequently unit iteration. He says that this is achieved when sub-division is generalised to cover transitive relations between successive portions of a given length, and change of position is generalised to cover comparison of parts. Generalised sub-division therefore enables the child to think of a unit as forming a part of any number of wholes, that is, as an elementary common part. But this can only be achieved together with generalised change of position, which enables the child to conceive of the unit part as being applied indefinitely in a continuous and contiguous series of changes of position. Unit iteration, which is the basis of measurement, therefore depends on the synthesis of operations of change of position and sub-division.

He points out that number, the arithmetical unit, is similarly a synthesis of a class and an asymmetrical relation. However, in the case of length, the notion of the unit involves the 'arbitrary disintegration of a continuous whole', and the elaboration of the metric unit is much slower than that of the arithmetical unit, and marks not the beginning of the achievement of operational thinking, as in number, but the final stage.

The test on conservation of length used in the present study is based on that described by Piaget <u>et al.</u> (1960) in Chapter IV of this work.

They first examined the question as to whether the estimation of length in terms of the interval between the end points of an object was itself the end stage of a developmental process. They studied this question by asking the children to compare the lengths of two sticks, one of which was straight and the other curved in a zig-zag fashion. The end points of the two sticks were made to coincide. The child was questioned as to whether or not the two sticks were the same length, and whether if two little men or ants were to walk along the sticks, they would have the same distance to walk. The child was encouraged to run his fingers along the sticks when comparing the lengths. The curved stick was then straightened, so that it was seen to be longer than the straight stick, and was then put back to its original position, the child being questioned after both these changes.

The following stages of development were distinguished:

<u>Stage I</u>

The younger children, up to about five years, judged the lengths in terms of their end points only. They therefore judged the lengths to be the same if their end points coincided, regardless of the rectilinearity or curvilinearity of the lengths. They state that this cannot be explained as due to the failure of the child to differentiate between the length of the line and the rectilinear distance between its end points, since they have shown that at this stage the child ascribes distance only to empty spaces, and that distance itself is not judged in terms of the relation between the end points, but only in terms of the point nearest or furthest from the subject. They therefore explain the responses of this stage as due to the fact that the child fails to take into account the composition of lengths, so that his criterion of length is based only on the order of the end-points. The child's judgement is not influenced by the suggestion of movement, either in the case of the little men or ants walking along the sticks, or when he is asked to run his finger along the sticks. When the curved length is straightened he immediately sees that it is longer than the straight stick, but as soon as it is returned to its original position he again judges it to be the same length as the straight stick.

Stage II A

At this level the child shows the first intuitive compositions of length in that he judges that the curved stick is longer when movement along the stick is suggested. However, he reverts to his judgement that the sticks are the same length when he makes a judgement of the static situation.

Stage II B

The child achieves a correct solution by means of intuitive articulations. Piaget argues that composition of length at this stage is still intuitive since the children's judgements are still expressed in terms of the end-points, i.e., the children judge that the curved stick is longer because if it was straightened it would 'jut out'.

Stage III

At this stage the child achieves operational composition of the lengths. However, in this test responses at Stage II B and Stage III are not distinguished, and presumably it is not always possible to determine whether a correct answer belongs to Stage II B or to Stage III.

Piaget then goes on to study conservation of length. He first showed the subjects two straight sticks of equal length, placed parallel and with their ends coinciding. The children all judged the sticks to be the same length. One stick was then moved forward one or two cms., and the child was asked if the two sticks were the same length, and if not, which was longer. The sticks were also placed in various other positions, e.g., at an acute or right angle, to form a T, and with one placed oblique to the other.

On the basis of the children's responses the following stages of development were distinguished.

Stage I and Stage II A

Initially the children failed to take account of both ends of the stick simultaneously, and judged length only in terms of the order of their end points. Piaget points out that these judgements are related to topological intuitions of spatial order rather than to Euclidian concepts of change of position which imply conservation of length.

The majority of the children followed the leading extremity of the moving stick with their eyes, and so judged the stick that had been moved to be longer, since it was now 'ahead' of the other stick.

Some of the children attended to one side only, and judged according to which stick overlapped the other at this side, regardless of whether this was the stick that had been moved or the stationary stick.

Other children simply judged that the stick was longer because it had changed its position, without troubling to examine its point of arrival. If both sticks were moved, then both sticks would be judged to be longer.

A few children concentrated on the trailing end of the moving stick, and thus judged the stationary stick to be longer since it now overlapped the other.

Piaget states that these results indicate that non-conservation of length can be attributed to the absence of an independent reference system to which the movement can be related. The child cannot relate the movement to such a reference system since he is unable to take into account the interval between the two extremities of the stick. Since the child is unable to take account of the interval between the end points, or to relate the change of position to a reference system of fixed sites, his judgements of length can be made only in terms of the relative positions of their end points, i.e., of static relations of order.

Stage II B

At this level a number of responses intermediate to those of the previous and the subsequent stages are found. These responses result from a number of intuitive regulations which precede the development of operational conservation. The following transitional stages are distinguished.

1. A perceptual regulation, such that where the stagger is less relative to the total length of the sticks, a judgement of equality may be made.

2. An intuitive regulation which results from the decentring of attention, such that the child notices that when one stick is longer on the left, the other is longer on the right. This regulation marks the beginning of a relationship between the two extremities. Some of the children are able to achieve an intuitive conservation by means of this regulation, while others may resort to judging that both sticks are now longer.

3. A more advanced intuitive regulation is found when the child recognises that the sticks are equal when both are moved simultaneously in opposite directions, but not when only one stick is moved.

4. An empirical reversibility is shown by some children who return the sticks to their original position before judging that they are equal. Piaget maintains that this action illustrates the child's uncertainty as to conservation, and that the action of returning the sticks to their original position does not imply operational reversibility but is simply an intuitive return to the

starting point. However, this response foreshadows operational reversibility.

5. Finally a number of responses are found where the child eventually achieves a tentative conservation by intuitive compensations derived from contradictory comparisons. However, these responses are distinguished from those at the operational level, since at this level the children do not regard conservation as logically necessary, and their conservation is not based on an exact compensation of the spaces left empty and the corresponding spaces that are filled. The children simply guess at conservation on the basis of intuitive compensations.

Stage III

At this level operational conservation based on composition of length is found. This is achieved when the child is able to compose and co-ordinate empty and filled spaces and to relate changes of position to a system of fixed sites. While a number of children appear to base their judgement of conservation on simple identity ('They are the same because they were the same before') Piaget points out that at earlier levels the children knew that the sticks were the same but did not show conservation, and thus identification is not in itself sufficient to ensure conservation. Some of the children who are in the process of achieving conservation or who have just achieved it give responses which indicate how they arrived at conservation. The explanation 'They're both the same but they're placed differently' illustrates the subject's recognition that a change of position does not involve simply a changed positional order, but must be related to a fixed reference system. Exact compensation of filled and empty spaces is illustrated by references to the fact that the space left empty by the movement is exactly compensated by the space now filled, so that the overall length of the object remains constant.

B. Conservation of Area

Piaget maintains that conservation of area depends on the same basic operations as conservation of length, i.e., the development and co-ordination of operations of order and change of position and operations of sub-division, which in turn depend on the recognition of a common spatial medium which provides a system of fixed sites as a framework of reference. They point out that a direct study of conservation of area is difficult, since physically an area cannot be entirely dissociated from the physical object and the children's use and understanding of the terms referring to area cannot always be interpreted with certainty, since they may be confusing area with some other dimension or with matter as such. An example of such a confusion is illustrated by the response of Cri (five years six months): '...No, there's more room on here (intact rectangle) because there (the other figure) its thin...' (Piaget et al. [1960] p.276). In this case the child is confusing the thickness of the cardboard with its surface area.

Piaget suggests that this inability to differentiate area from solid matter is related to the inability of children at this level to dissociate the notion of a 'site' from the object which occupies this site.

A further difficulty in understanding the notion of area is that a rearrangement of parts results in a figure that is qualitatively new, and whose perimeter will be altered with a change in form.[1] It is therefore more difficult to abstract 'area' from the shape enclosed by a given perimeter, than to abstract, for example, 'number' from a given set of discrete objects. While a similar difficulty is also present in the case of length, it is possible in this case to introduce the concept of movement to dissociate the notion of length from qualitative shape.

Because of the possible ambiguity of the children's responses in the direct study of conservation of area, the investigation of conservation of area was started with a study of composition of areas in a situation where complementary areas could be made congruent by a rearrangement of parts.

In this test two identical sheets of green cardboard, representing fields of grass, were set before the child, and a wooden cow was placed in each field. The children all agreed that the two cows would have the same amount of green grass to eat. A wooden house was then placed in one field, and all the children agreed that this field would now have less grass for the cow to

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1 The child's understanding of the relation between area and perimeter in transformations of a figure enclosed by the same length of string has been studied by Vinh-Bang (1965).

eat, since the house covered a part of the grass. An identical house was then placed on the other field and the children understood that the two cows would now have the same amount of grass, since each had an identical house on his field. The procedure was then to continue adding one house to each field simultaneously, the houses in one field being placed side by side in one corner of the field, and the houses in the other field being placed at random, thus giving the perceptual appearance of a larger amount of green on one field than on the other. After each pair of houses was added the child was questioned as to the equality of the amount of grass that the two cows had to eat.

The following stages of development were distinguished:

Stage I

Not possible to pursue the enquiry.

Stage II A

At this level the children refused to admit that the remaining areas of grassland were equal when the position of the houses on the two fields was different. This was sometimes noted with the very first pair of houses if the position of one of the houses was altered after the child's initial judgement of equality. Some children recognised the equality of the remaining grassland up to two or three houses. Piaget states that the elementary composition of this initial identity is dependent on 'quasi-perceptual anticipations or reconstructions', which are dependent on perceptual mechanisms and are not based on images or representation.

Stage II B

At this level a range of intermediate responses was found; up to a certain number of houses the children would admit that the remaining grassland was equal, but at a certain point the influence of the perceptual configuration became too strong, and the child judged that the field with the greater apparent expanse of green had more grass, even though he knew that the number of houses on the two fields was equal. Some of the children showed a continual conflict between operation and intuition, in that as soon as they were reminded of the equality of the houses they judged identity of the remaining grassland, but at the next moment or at the next pair of houses they judged non-equality until they were again reminded of the equality of the houses.

Piaget states that the articulated intuitions of this stage are due to elementary transformations, which are distinguished from true operations in their lack of mobility, reversibility, and generalisation. Thus the identity of the remaining grassland based on the equality of the houses has to be worked out for each new situation, and may break down when the child's attention is diverted from the equality of the houses to the apparently greater expanse of grassland in one field.

Stage III

At this stage the child shows immediate operational composition, through which the equality and hence the conservation of the remaining areas is recognised as logically necessary, and is extended to any number of houses on the field.

A complete continuity was shown in the almost imperceptible gradation from complete failure of all composition, through elementary composition based on perceptual regulations and intuitive regulations, at first simple, based only on a static image, and then articulated, based on elementary transformations, and finally to operational composition which is generalised to all situations. 'Each new brick which can be added without disturbing the recognition of equality marks a step forward in development...' (Piaget et al. [1960] p.267).

They state that conservation of area is found at the same level as conservation of length, since they depend on the same basic operations.

The present problem requires compositions of area by adding and subtracting parts which are sub-divisions of a whole, but Piaget states that the failure to solve this problem is due to non-conservation. That is, the children fail to understand that equal parts subtracted from equal wholes leave equal remainders because they do not conserve the areas of the houses when their positions are changed, nor the areas of empty space when the parts are rearranged. The solution to this problem therefore depends on conservation.

In analysing this problem, Piaget concludes that the conservation of the grassland requires co-ordination between the area of the houses and the complementary area of grassland. This he states can only be achieved by the construction of a co-ordinate system of reference. However, he had previously determined that the construction of such a system is found only at Stage III B (nine to ten years), although this problem is successfully solved at Stage III A (seven years). He therefore has to explain why the children are able to solve this problem at this level.

He therefore undertook a second study of composition of area, in which the total area was an irregular figure, and the enclosed area was made up of parts which could be fitted together in different ways. This was presented as a potato plot, which could be made square or rectangular by the rearrangement of its parts, and which was placed in the middle of a field of grass. In this case he found, as he had predicted, that conservation of the enclosed area (the potato plot) was found at Stage III A, while conservation of the complementary area (the remaining green field) was found only at Stage III B, when the child was able to construct a complete system of reference to co-ordinate the complementary areas.

Piaget suggests that in the case of the identical houses the problem is made easier for the child because the identity of the houses is pointed out to him at the start of the test, and his attention is immediately directed to the remaining area, to which he can apply the relevant operations. He suggests that the problem of the potato plot is more difficult for the child because he has first to solve the problem of the enclosed area, and his attention is not directed to the complementary area. He states that the child has therefore to solve two separate problems, and does not receive any guidance from the experimenter as to the complementarity of the areas.

6. Discussion of Piaget's Theory of the Development of Conservation

In the preceding discussion an attempt has been made to present Piaget's theory of the development of conservation as understood from the various writings of Piaget and his collaborators. No attempt has been made to evaluate this theory, and such an evaluation will be left to the final section of this work when his theory will be discussed in relation to the findings of other studies and of the present study. However, it does seem to be necessary at this point to note some of the apparent inconsistencies or confusions in the theory as it has been outlined here.

1. Piaget's emphasis on the interdependence of the various developing processes frequently appears to result in a circular argument, i.e., A is the cause of B and B is the cause of A. This tendency is also noted by Flavell (1963), who states:

> Although Piaget is not as specific and clear here as one might wish, the presumption is that the circle just avoids being a vicious one by virtue of the fact that development proceeds by very small increments; tiny advances in one area (via the usual mechanism of decentration with progressive equilibration etc.) pave the way for similarly small advances in another; these advances then redound to the developmental advantage of the first area, and so the spiral continues through ontogenesis (Flavell [1963] p.318).

Piaget attributes this circular argument to the child himself. With reference to conservation of area and volume he states:

> The argument is circular, since compensation between empty spaces and newly occupied spaces depends on the invariance of area and volume despite changes in position, and the latter depends on the awareness of compensation. But although circular (and the same is true of the conservation of length) it is this reasoning which enables the child to co-ordinate sub-division and change of position, and hence to recognise the conservation of area and volume when objects are subjected to modifications of shape (Piaget et al. [1960] p.395).

Reversibility is also seen to be interdependent with other developments, such that it both leads to and is itself dependent on the development of other processes.

In considering this problem it should be noted that Piaget's main concern is to uncover the processes of development, rather than to specify the precise causes of development. In describing the interdependence of thought processes he is therefore describing what he finds to occur in the development of these processes.

2. Piaget's distinction between logical operations and physical or infra-logical operations does not appear to be entirely consistent. In his work on the development of physical quantities (Piaget and Inhelder [1962]) and on the conservation of continuous quantities (Piaget [1952]) he makes it quite clear that while the invariance of the physical quantities depend on physical operations, the conservation of these quantities depend on logical operations. He also states that both logical and physical operations are found in every logical and in every physical construction. However, in his work on

spatial concepts and on the conservation and measurement of length, area and volume he makes no reference at all to logical operations, and appears to state that the conservation of these qualities is entirely dependent on infra-logical operations. This gives rise to the apparent inconsistency that conservation of the volume of a plasticine ball is said to depend on logical operations, while conservation of the volume of a block made up of unit blocks depends on infra-logical operations. This apparent inconsistency may be due simply to a difference of emphasis. That is, Piaget may recognise that in all cases conservation is dependent on the simultaneous development of both logical and infra-logical operations, but in some cases he confines his discussion to the development of one set of operations, and in other cases concentrates on the development of the other set of operations. For example, it would appear that in order to be consistent with his earlier writings, the establishment of the invariance of the parts making up a length or an area should be attributed to infra-logical operations, while the conservation of length or area should be attributed to logical operations applied to the invariant parts of length and area which have been constituted by the infra-logical operations. However, in his discussion of the conservation of length and area Piaget makes no reference to logical operations.

On the other hand, it may be questioned whether he intends to imply by logical and infra-logical operations two separate sets of operations, or whether he intends to imply only one set of operations which when applied to discrete objects become logical operations and when applied to a single continuous whole become infra-logical operations. His distinction between logical and infra-logical operations in his study of space (Piaget and Inhelder [1956] pp.457-63) would appear to support the first of these possibilities, while his discussion of the relation between logical and physical operations in the case of physical quantities (Piaget and Inhelder [1962] pp.271-80) would appear, in parts, to support the second possibility. Which of these interpretations is correct is therefore not clear from his writings.

3. Piaget's explanation for the discrepancy in his findings on the conservation of complementary area in the case of the houses and in the case of the potato plot would seem to be dubious on several grounds. These are:

1. The initial identity of the potato plots is pointed out to the child, just as the identity of the houses is pointed out, and the child recognises the equality of the complementary areas so long as the shape and position of the plots is identical, just as he recognised the equality of the complementary ares when the houses were placed in identical arrangements on the two fields.

2. The fact that the identity of the houses is pointed out to the child does not necessarily imply that he conserves the area of the houses. In fact, Piaget noted that the child may judge that when the houses are scattered there are more houses. This tendency was also found in our own results. It cannot therefore be

assumed that in the case of the houses the equality of the area of the houses is accepted by the child, and that his only problem is that of the complementary area.

3. The child's attention is directed to the complementary area in the problem of the potato plots as soon as he is asked if the remaining area is equal, just as his attention is directed to the complementary area in the case of the houses.

4. If the conservation of the complementary area depends on the co-ordination of the partial and the complementary areas by means of a co-ordinate system of reference, the child should be unable to solve this problem operationally before he is able to construct the necessary co-ordinate system, regardless of whether or not his attention is directed to the complementary area.

The only essential difference between these two tests appears to be that in the case of the houses the partial area is made up of identical units which can be counted, whereas in the case of the potato plot the partial area is not sub-divided into units and there is no way of checking its equality once the parts are rearranged. It may therefore be suggested that the earlier solution of the first problem may be based on an intuitive understanding that so long as the number of houses are the same, the remaining areas must be equal. This solution cannot be classed as an operational solution, since at this stage, according to Piaget, the child lacks the co-ordinate system of reference by which the partial and complementary areas are co-ordinated, and which is necessary for the operational conservation of the complementary area.

The question as to whether the irregularity of the total area in the second problem affects the child's ability to solve this particular problem is not clear from the findings reported, and it would require a further investigation to answer this question.

CHAPTER III

REVIEW OF RELATED STUDIES

An increasing number of studies following up Piaget's work have been and are being undertaken. Flavell (1963) has presented an extensive review of these studies. For the present purpose only a brief indication of the main directions taken by these studies will be given. A consideration of some of the more important implications which they raise for Piaget's theory of development will be deferred until the final discussion.

Four main types of study can be distinguished:

1. Replicative studies.
2. Experimental studies.
3. Learning studies.
4. Cross-cultural studies.

1. Replicative Studies

These include the studies of Lovell and his associates on the development of concepts of substance (Lovell and Ogilvie [1960], weight (Lovell and Ogilvie [1961a]), volume (Lovell and Ogilvie [1961b]), time (Lovell and Slater [1960]), speed (Lovell, Kellett and Moorhouse [1962]), and geometrical concepts (Lovell, Healey and Rowland [1962]); Lunzer's (1960a) study on volume; Elkind's (1961a, 1961b, 1964) studies on quantity, weight, volume and seriation; Dodwell's (1960, 1961, 1962) studies on number and Peel's (1959) study on space and other concepts.

These studies generally confirm the stages of development described by Piaget, and his age placings, although certain minor divergences are reported. Lovell and Slater (1960) and Dodwell (1960) both report that the developmental sequences are not as clear cut as supposed by Piaget, and that a child may perform at different levels on different tests. Lovell and Ogilvie (1961b) suggest that the understanding of a concept may depend on the situation in which the problem is posed. Lunzer (1960) questions Piaget's theory of the interdependence and interrelatedness of the various concepts. The invariant order of development for the conservation of quantity, weight and volume is confirmed by Lovell and Ogilvie (1960, 1961a, 1961b) and by Elkind (1961a).

While the confirmation of Piaget's stages and age placings is an important contribution, these studies have generally failed to go beyond Piaget's initial findings or to contribute in any positive way to the further development of his theory.

2. Experimental Studies

These studies employ strictly experimental procedures, often including training trials and reinforcement, and verbal instructions are usually restricted to a minimum. They include the studies of Braine (1959), Wohlwill (1960), and Yost, Siegel and Andrews (1962). The shortcomings of these studies is that they tend to oversimplify and distort Piaget's concepts. For this reason many of these studies could be referred to as pseudo-Piaget studies. For example, Braine (1959), in his study of transitivity of length, appears to train his subjects merely to respond to the longer of two sticks, rather than to make the transitive inference A>B, B>C, ∴ A>C. That is, the child may be making the inference; 'If I choose the stick longer than the measuring stick I'll get a piece of candy', and not the transitive inference that Braine purports to be studying; 'A is shorter than the measuring stick, and B is longer than the measuring stick, therefore B is longer than A.'

Yost, Siegel and Andrews (1962) apparently fail to understand what Piaget means by probability, and use a different criterion to that used by him. The concept of probability studied by Piaget implies a differentiation between chance and non-chance events, and a gradual understanding and application of the laws of probability. Yost, Siegel and Andrews are concerned only with whether the child is able to make significantly more correct responses than incorrect responses in a prediction-choice situation. Since correct predictions could be made on bases other than a true understanding of probability (for example, the total number of objects), and since an understanding of probability in Piaget's terms would not require a significantly greater number of correct responses, but consistently correct responses in all situations, the Yost, Siegel and Andrews study fails to touch on Piaget's notion of probability, and their conclusions in terms of Piaget's theory are unjustified.

This has been pointed out by Offenbach (1965), whose findings on children's ability to understand probability concepts offer some support to Piaget's views. Goldberg (1966) replicated the Yost, Siegel and Andrews study with some modifications, and found that in four to five year old children probability judgements are highly dependent on the task conditions, their choice is influenced by colour preferences, and there is a confusion between number and proportion. These findings give strong support to Piaget's views on the development of probability.

While these particular studies are not directly relevant to the present investigation, they raise general problems of procedure and methodology which are relevant to all studies based on Piaget's work.

Wohlwill (1960) studied the development of number concepts using experimental procedures and the Guttman scalogram technique. He states that his findings confirm Piaget's theoretical view that there is a relatively uniform developmental sequence in the achievement of the concept of number. However, he points out that the concepts studied by his techniques may not be identical to those studied by Piaget.

Kofsky (1966) has analysed the results of children's performances on a number of classificatory tests, based on those of Inhelder and Piaget (1964), by the scalogram technique. She does not find strong support for an invariant order in the solution of these tasks, and supports the views of Lovell, Dodwell and Hyde that the sequence of the mastery of cognitive tasks may vary with the individual. The performance may also have varied according to the order of presentation of the tests, which was randomised.

3. <u>Learning Studies</u>

This group is the most significant and important of the Piaget studies, and includes studies of the effects of training and of the situations in which the problems are posed. It includes further research being undertaken at Geneva, the numerous studies of Smedslund, those reported by Bruner (1964), Halpern's (1962) study, and the learning studies of Churchill (1958), Harker (1960), Beilin and Franklin (1962), and Wohlwill and Lowe (1962).

Some of these studies report that training can lead to improved performances (Churchill [1958]), while others find that training generally has little effect (Wohlwill and Lowe [1962]).

Smedslund (1959, 1961, Part I) has reviewed the studies on the effects of training carried out at Geneva by Greco, Morf, Wohlwill and himself, and from these he draws the following tentative conclusions:

1. For operational learning to occur the problem should present a relatively severe 'cognitive conflict', and should not be soluble by means of the schemas already possessed by the child, by means of simple discriminatory learning or by empirical short cuts to the solution.

2. The problem should be soluble by means of some relatively simple combination or differentiation of already existing schemas.

Smedslund (1961) carried out a series of experiments on the acquisition of conservation and transitivity of substance and weight.

He found that direct experience in checking weights after transformation and after addition and subtraction of small pieces of plasticine led to little improvement in performance. Repeated experience in finding that larger objects were not necessarily heavier than smaller objects also failed to improve performance.

An experiment designed to check his hypothesis that it is the presence of cognitive conflict that leads to the intellectual reorganisation necessary for conservation gave positive results. In this experiment the children were confronted with a situation in which two kinds of transformation were set in opposition to each other. The conflict was induced by the simultaneous deformation of an object and additions to or subtractions from another or the same object. For example, if the child thought that elongating a plasticine ball increased its quantity, a piece of plasticine was subtracted at the same time as it was elongated. No reinforcement was given, the child never being told whether his answer was right or wrong. Smedslund found that of the five children who based their judgements on whether or not any plasticine had been added or subtracted, four showed conservation on a post test, while of the eight children who based their judgements on the change in shape, none showed conservation in the post test. While the numbers involved were small, Smedslund points out that such shifts from non-conservation to conservation with logical justification have been rare in his experiments, and that these results therefore indicate support for his hypothesis that cognitive conflict induces development.

Further support for this hypothesis is obtained by Smedslund's last study in this series, and by Gruen (1965).

Smedslund also compared the reactions of children who showed initial conservation and children who had achieved conservation after training to an apparent contradiction of the principle of conservation. This was achieved by the experimenter removing a small piece of plasticine during deformation without the child's knowledge, so that subsequent weighing showed that the deformed ball, previously weighed and found to be equal to the other, was now lighter. All of the children who had acquired conservation only after training showed little surprise at this result and immediately reverted to non-conservation judgements. Approximately half of the initial conservers resisted the apparent contradiction of conservation and argued that some of the plasticine must have been taken away or must have dropped on to the floor.

Related to this study is that of Halpern (1962), who tested children who had achieved conservation and transitivity of weight on a series of tasks where the perceptual configuration competed with the logical inference. Her subjects were divided into two groups on the basis of their explanations; an empirically oriented group giving explanations referring to perceptual features of the situation, and a deductively oriented group giving explanations referring to previous events in the test situation (symbolic explanations). She found that the empirically oriented group made more errors on the tasks than the deductively oriented group.

She states that the errors of the empirically oriented group may be due to an intermediate stage of development, or to a tendency to rely on perception which may continue to operate at all levels of development.

Halpern concluded that the dominance of perception may continue into the stage where concrete operational thinking is already evident, and that the progress from pre-operational to operational thinking may be more gradual than supposed by Piaget and Inhelder. She suggests that their theory that older modes of thinking are abandoned in favour of newer ones in the course of development requires modification.

Halpern does not use strict criteria for conservation and transitivity. For conservation, she requires success on seven out of eight transformation items, only one of which involved a marked change of form. Her tests for transitivity were preceded by an initial training period. Smedslund (1959) has found a high correlation between perceptual explanations and incorrect answers. This suggests that many of Halpern's empirically oriented group may not have achieved genuine conservation, or may be at a transitional level of development. This weakens her conclusions with regard to the theoretical implications of her findings.

Wohlwill and Lowe (1962) made a study of the effects of various types of training on the acquisition of conservation of number. They found that none of their training methods resulted in any significant improvement in performance in any one group, but that there was an overall improvement in performance for all the groups from pre- to post-tests. This improvement occurred in the control group (no training) as well as the training groups. However, their tests involved matching the number of objects to a numeral, and this seems to be a doubtful test of Piaget's principle of conservation. Wohlwill and Lowe recognise this limitation, and make the important point that it is incumbent on those applying non-verbal methods to determine the depth of the child's understanding of the concepts in question in these situations.

Beilin and Franklin (1962) studied the effects of group instruction on the measurement of length and area for two age groups, six to seven years and eight to nine years.

The main conclusions of their study were as follows:

1. Measurement of length was achieved before measurement of area.

2. The effect of group instruction depended on the level of development: none of the younger age group showed success in measuring area after instruction, although some showed improvement from non-conservation to transitional responses. In the older age group, a number of the instructed group were successful in the post-test on area, while the non-instructed group showed no improvement.

3. The Piaget testing situation itself may act to facilitate the acquisition of the operations in question, since improvement was also found in the control groups.

This was noted particularly in the case of length in the younger age group.

4. They suggested that the effect of group instruction or experience on the tests may be more marked at the younger age levels among the more intelligent children, while at the later age levels, where the achievement of the concept in question was fairly general, intellectual factors were not so crucial a determinent.

5. They suggested that the calculation of length, area and volume is achieved in this order, and that the order of achievement is a function of the added dimensions. This is in opposition to Piaget's finding that the operations relevant to length and area are achieved at the same time.

Finally in this section reference may be made to one of the studies reported by Bruner (1964), the experiment of Frank on the conservation of quantity. She presented Piaget's test using glasses of liquid, and then repeated the experiment with the glasses screened so that the levels of liquid were not visible. She found a striking increase in the percentage of conservation judgements, and when the screen was removed she found that only the four year old children reverted to non-conservation, virtually all the five year olds and all the six and seven year olds sticking to their conservation judgements and giving adequate explanations of conservation.

A post-test a few minutes later without the screen showed the following improvements from the initial unscreened test:

4 years	No conservation responses		
5 years	20%	to	70%
6 years	50%	to	90%
7 years	50%	to	90%

A control group showed no significant improvement in performance from pre-test to post-test.

This is an extremely important finding and requires further investigation. In particular, a replication of this study with a series of post-tests carried out days, weeks, and months later should be carried out to determine whether this effect is stable and lasting. A study could also be carried out to determine whether this experience will lead to conservation in other situations as well. These results are not supported by those reported by Greenfield on West African children (see p.123).

4. Cross-cultural Studies

Only a limited number of cross-cultural studies using Piaget's techniques have been reported. The most important are those of Goodnow (1962) and of Hyde (1959). In addition, studies on African children have been reported by Price Williams (1961, 1962). The present author has also undertaken a study of the development of spatial concepts in African and European children (Murray [1961], Cowley and Murray [1962]). A further study which is relevant to Piaget's theory is that of Kidd and Rivoire (1965), who have reviewed a number of cross-cultural studies of tests involving spatial concepts and have analysed the performance on these tests in terms of Piaget's theory of the development of topological, projective and Euclidean concepts of space.

Goodnow's (1962) study is the most careful and decisive study yet reported in the application of Piaget's tests to other cultural groups, and her findings are of importance to cross-cultural comparisons of intellectual development. Her main findings can be summarised as:

1. There is little difference in conceptual development in European and Chinese schoolboys.

2. On the conservation tests (area, weight, volume) Chinese children who had not attended school did better than those who had attended school.

3. On the combinatorial test (from Piaget's work on chance) and on the Raven Matrices, the performance of the Chinese children attending an English medium school was comparable with that of European children, those attending a Chinese medium school showed slightly poorer performances, while those not attending school showed very poor performances.

Goodnow suggests that the Raven Matrices and the combinatorial test are correlated with general intelligence, and that the conservation tests may involve some kind of 'intellectual constancy' similar to perceptual constancies and correlated with chronological rather than with mental age.

This view seems to be untenable in view of Inhelder's (1944) findings on the feeble-minded, and the findings of Woodward (1961) Lovell and Slater (1960) and

Lovell, Kellett and Moorhouse (1962) on sub-normal children and adults.

A more reasonable explanation for her findings would be that performance on the Raven Matrices and combinatorial test depends on schooling, while performance on the conservation tests does not. This would support Piaget's view that intellectual development depends on the child's general interaction with the environment rather than on specific school learning.

Hyde(1959) applied Piaget's test on conservation of substance, weight and volume, and a number of his tests on number, to Arab, Somali, Indian and European children living in Aden. Her study is unfortunately inconclusive, owing mainly to the small number of children tested at each age level, and the restricted age range (six to eight years) that she studied. She found the same stages of development and the same types of response as described by Piaget, but she found that operational responses were achieved more readily on some tests than on others, and some children showed operational responses on some tests and pre-operational responses on other tests.

Hyde did not find strong evidence for the invariant order of development of quantity, weight and volume postulated by Piaget and Inhelder. However, the order of presentation of the tests was randomised, and it is possible that the reversals in this order that occurred may have been caused by the children's experience on the previous tests.

Hyde's definition of her three stages of development does not always seem to correspond very closely to Piaget's, and her definition varies slightly from test to test. In some cases she finds transitional responses at the youngest age levels, followed by pre-operational responses at older levels, and on some tests she found more transitional responses than either operational or pre-operational responses. This suggests that some of the tests may not have distinguished satisfactorily between pre-operational and operational responses, and that the classification on these tests may not be very reliable.

Price Williams (1961, 1962) reported two studies on the application of Piaget's techniques to African children. The first dealt with the conservation of continuous and discontinuous quantities and number in a group of illiterate West African bush children. The children's ages ranged from about five to eight years. The children were tested by the investigator in their own language, after the questions to be used had been discussed with teachers familiar with the language. He found that conservation of continuous and discontinuous quantities was generally found at about eight years, while conservation of number was generally found at about seven years, and that the explanations given by the children for both their non-conservation and their conservation judgements were similar to those reported by Piaget. He therefore concludes that Piaget's theory of stages of development and the approximate ages at which these stages are found are applicable to African children. Since the children he tested had had no formal instruction, he suggests that his results may indicate a neuro-physiological interpretation of 'readiness' to deal with such concepts. However, he points out that the children were familiar with a game involving number.

This study would seem to suggest that conceptual development in African children parallels that of European children, both in regard to the stages of the development and the ages at which these stages are found. However, our own study on African children (Cowley and Murray [1962]) suggests that this is not the case in all areas of development and that conceptual development in some areas may be found at a later age in African than in European children. In assessing Price Williams' study it should be borne in mind that his tasks were relatively simple, and that more complex tasks, involving greater numbers or more complex situations may reveal other differences in development between African and European children. Such differences might be expected in view of the great differences in their cultural and environmental backgrounds.

Price Williams' (1962) second study was on abstract and concrete modes of classification found in two groups of West African children, one group attending school, the other not attending school. His definition of 'concrete' and 'abstract' is based on that of Goldstein and Scheerer (1941). He attempted to relate this classification to Piaget's theory, equating concrete modes of classification with pre-operational thinking, and abstract modes of classification with concrete-operational thinking. However, he found marked differences in the number of children making concrete and abstract classifications for plants and for animals, which suggests that these classifications may have depended on other factors, such as conventional forms of classification or naming, and not on the presence or absence of operational thinking.

Price Williams' experiment and his method of scoring therefore throw little light on whether or not the children are able to form true hierarchical classes and to understand the problem of logical class inclusion, necessary to Piaget's concept of classification.

Greenfield[1] has applied Piaget's test on conservation of quantity to Senegalese children. She found that by 11 or 12 years all the school children, but only about half of those not at school, had achieved conservation. Screening the glasses (see Frank's experiment p.118) had a relatively minor effect on non-conservation responses. She found a tendency for magical explanations to be given by the unschooled children.

These findings conflict with those of Price Williams on the age at which conservation of quantity is achieved in unschooled African children.

Kidd and Rivoire (1965) related Piaget's distinction between topological, projective and Euclidian spatial concepts to a number of studies using so-called 'culture free' tests. From a number of items which various investigators have found to be 'culture fair', they

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1 Reported in the Fifth Annual Report of the Harvard University Centre for Cognitive Studies, 1965.

selected those which could be classified in terms of elementary topological transformations. These were compared with a number of items which were found to discriminate decisively between ethnic and socio-economic groups. They found that those items which were 'culturally weighted', contained, in addition to the topological transformations of the culture fair items, overlying projective and Euclidian properties that obscured the basic topological properties. They concluded that the most elementary forms of spatial perception are common to all cultures, and are left untouched by the material aspects of the culture. They therefore suggest that in comparing the abilities of children from widely varied backgrounds, items constructed on the basis of elementary topological properties only should be used.

These findings support Piaget's theory that spatial concepts develop from topological forms to projective and Euclidian forms. They also suggest that in some cultures the development of spatial concepts may not proceed beyond the level of topological concepts, which are developed prior to Piaget's stage of concrete operations. This suggests that the stage of concrete thinking may not be developed in such cultures, or may be only imperfectly developed, or if developed is not necessarily applied to all areas of conceptual thought. This is supported by a previous study by the present author (Cowley and Murray [1962]), where it was found that few Zulu children up to the age of 12 years reach Piaget's stage III in the development of spatial concepts, this stage marking the level of concrete thinking and the development of projective and Euclidian concepts of space.

Kidd and Rivoire apparently fail to perceive the implications of their results for the assessment of intellectual abilities. If the failure to solve items involving Euclidian concepts indicates a prior stage of intellectual development, these items must be crucial to any estimate of intellectual capacity. One can hardly exclude the very items that reveal basic limitations in intellectual development from a test of intellectual abilities. The failure to solve these particular items may relate to important differences in intellectual development which might have a profound influence on other intellectual abilities. A 'culture-free' test devised by the process of excluding any items which discriminate between ethnic groups, regardless of whether or not these items are measuring important intellectual capacities or not, would be quite meaningless.

Problems raised by the Piaget Studies

The general problems that have been raised by the various investigations following up Piaget's work include questions on whether or not Piaget's stages of development are qualitative or quantitative, the distinction between intuitive and operational solutions, the criteria for the presence of the concrete operational stage, the relationship between performance on the different tests, the effects of learning and experience, and the variations in performance according to the particular experimental situation.

Most of these problems can be related to three main questions:

1. The continuity or discontinuity of the stages of development.
2. The intuitive stage of development.
3. The interrelationships between performance on different tests.

These three questions are in fact all related, and all hinge on the first question of the continuity or discontinuity of the stages of development.

These problems will be discussed in relation to our own findings and their implications for Piaget's theory of development in the final section of this work.

PART II

THE STUDY

CHAPTER IV

THE SAMPLE

The sample was composed of two groups of Aboriginal children living on Mission Stations in the Northern Territory of Australia. One group was tested at Hermannsburg Mission in Central Australia, the other group at Elcho Island Mission in north-east Arnhem Land.

This chapter will deal with the background of the sample, and will be divided into the following sections:

1. General Cultural Background.
2. Present Conditions of the Aborigines in the Northern Territory.
3. Environmental Background of the Children Tested.
    1. Hermannsburg.
    2. Elcho Island.
4. Intellectual Capacity of the Aborigines.
5. Characteristics of Aboriginal Languages.

1. General Cultural Background

The Aboriginal culture has been extensively studied and reported. The earliest studies include those of Spencer and Gillen (1899, 1904, 1927) and Basedow (1925) on tribes in Central Australia. Later studies have been carried out by Elkin (1943), Kaberry (1939), Warner (1958), Meggitt (1962), and others.

No attempt can be made here to review this literature, but a brief outline of some of the main characteristics of traditional Aboriginal culture will be given.

The Aborigines were basically a hunting and collecting nomadic people. They developed no agriculture, neither planting crops nor herding animals. Exchange of goods did take place, but this was mainly of social and ritualistic importance. No real trade or barter system was developed.

The Aboriginal tribes were strongly attached to their own particular 'territory' so that movement of tribes and contact between tribes was relatively limited. While there seems to be some disagreement as to the basic constitution of the traditional Aboriginal community (see Elkin in Meggitt [1962]), the view appears to be generally held that the Aborigines lived in fairly large communities which hunted, camped, and performed corroborees together, but that smaller family groups would break away from the larger community for limited periods or in times of drought and food scarcity.

The Aborigines did not have permanent villages or camp sites, but moved from place to place. The people slept in the open, or made rough shelters of branches, bark and leaves. Worldly possessions were limited to what could easily be carried when the tribe moved on to a new site.

Weapons and implements made by the Aborigines include the throwing boomerang, spears, fighting sticks, digging sticks, shields, stone axes and fire sticks. Bags for carrying food and possessions were made by the women, usually from some kind of fibre string. Articles for adornment or for religious ceremonies were often made from human hair-string, fur or feathers. Sacred objects were generally made of wood or stone, decorated by simple designs, or, in north-east Arnhem Land, fairly elaborate paintings. The variety of material goods made by the Aborigines varied from tribe to tribe and from area to area, the north-east tribes generally having a richer variety of possessions and art forms.

The Aborigines had a complex social organisation and kinship system, and a rich variety of myths, totems, and religious ceremonies, rituals and beliefs. These aspects of Aboriginal culture have been dealt with at great length in the works on Aboriginal culture referred to, and also by Strehlow (1947) and Berndt (1951, 1952).

Children were taught from an early age to observe and practise the rules and obligations of social relationships. They were also taught the myths and beliefs of the tribe. This occurred particularly at the initiation of the boys, when they were required to learn the special sacred myths and songs of their particular totem, which could not be passed on to the uninitiated or the women. Such learning was always by rote, and the children were not expected to question or discuss what they were taught (Strehlow [1947]). Boys and girls learnt hunting and food gathering skills at an early age, mainly by imitation and observation, and were expected to help in these activities as soon as they were old enough to do so.

2. Present Conditions of the Aborigines in the Northern Territory

The Aborigines first contact with the Europeans began in the Nineteenth Century with the exploration and settlement of the Northern Territory. These contacts were at first limited, but with the establishment of missions, pastoral properties, ration depots, and more recently the government settlements, the Aboriginal people have gradually come into closer contact with the European.

The first mission in the Northern Territory was established at Hermannsburg in 1877. Following this a number of missions were established, mainly in the northern part of the Territory, from 1886-1938. The government ration depots and settlements were established mainly after the Second World War, and many of the larger settlements were established only in the late 1950s.

Population and Distribution

The total full blood Aboriginal population in the Northern Territory at 31 December 1962, was recorded as 18,671 (Welfare Branch Annual Report, 1962-3). Of this total, about 59 per cent were recorded as being in contact with government settlements and mission stations, and about 35 per cent were recorded as being in contact with pastoral stations. Only 8.1 per cent of the Aboriginal population were living in or near the urban centres, including the government settlements at Darwin and Alice Springs. In comparison, 74.8 per cent of the non-Aboriginal population, mainly European, were living in the urban centres (percentages quoted from Tatz [1964]).

The missions and government settlements are generally situated hundreds of miles from the European living and communication centres. Some settlements and missions can be reached only by air or by sea, and during the wet season in the north access by air may be cut off. In other cases access by road may be limited by weather conditions. The Aborigines therefore have little opportunity to come into contact with the European centres.

Housing

On the older established missions most of the Aboriginals are housed in simple one or two-roomed houses, made from a variety of materials according to the area. On the newer settlements many of the Aboriginals live in 'humpies' or 'wurlies', rough shelters made from whatever material happens to be available (Tatz [1964]). Most of the houses are completely unfurnished, and the utensils and material possessions of the Aborigines are few.

Health and Nutrition

Tatz (1964) points out that while reliable figures for the incidence of diseases among the Aborigines are not available, the available figures indicate a very high infant mortality, a high incidence of tuberculosis and leprosy, and a high incidence of infections such as hook-worm, diarrhoea, gastro-enteritis, and eye and ear infections. This he attributes largely to the poor housing conditions, lack of adequate water supplies and adequate sanitation, and an inadequate preventive health service. He also quotes figures by Crotty and Webb (1960) which indicate that malnutrition was a significant contributing factor in a high proportion of infant deaths (Tatz [1964] pp.132 and 153).

While all missions and settlements provide either rations or cooked meals for the Aboriginals, figures quoted by Tatz suggest that in most cases their diet would be deficient, particularly in protein. Crotty (1958) reports that 'anaemia associated with a kwashiorkor-like nutritional disease is common between one and five years of age' (Crotty [1958] p.325).

Education

Prior to 1950 the only education available to Aboriginal children was that provided by the missions. The mission schools were generally handicapped by a shortage of staff and lack of finance, and in many cases one teacher with a minimum of equipment and space was responsible for a large number of children. Since 1950 the government has established schools on settlements and pastoral properties, and has taken responsibility for supervising and assisting the mission schools.

While education facilities for Aborigines have greatly inproved since 1950, a recent report by Watts and Gallacher (1964) indicates that the educational achievement of Aboriginal children remains extremely low. Watts and Gallacher tested the children's reading comprehension, spelling, and arithmetic and number concepts. For these tests head teachers at 17 schools throughout the Territory were asked to select up to 20 of their best pupils, ranging in age from 8 to 15 years and over. They reported the following results:

1. On reading comprehension, it was found that only 23 per cent of children aged 12 and over were able to read at a level beyond Grade 4 (about 9 years in European children), and 54 per cent of children from 8 to 11 years could not read beyond the Grade 2 level (about 7 years in European children).

2. On spelling, it was found that the majority of children of 12 years and over were spelling at the 7 to 9 year old levels, and from 8 to 11 years the majority of children were spelling at the 6 to 8 year old levels.

3. A comparison of the scores of Aboriginal children on the number concept tests with those of Grade 1 children in New South Wales (5 to 6 years) indicated that while 67 per cent of the New South Wales children achieved a score of 15 to 24 on these tests, only 5 per cent of Aboriginal children classified at Stage II and 22 per cent classified at Stage III scored 15 or more. No Aboriginal children scored 20 or more. The ages of the Aboriginal children classified at these stages covered a wide range from 6 to 15 years.

On number concepts therefore few Aboriginal children even up to 15 years of age appeared to have reached a level comparable to that reached by the majority of white Australian children at 5 to 6 years. Performances on reading and spelling were better, but still much below the white Australian levels, with the majority of children up to 15 years and over performing only at 7 to 8 year old levels or lower.

It should be remembered that for these tests only the <u>best</u> pupils were selected from a number of different schools. The average overall performance of Aboriginal children would therefore be much lower than is indicated by these figures.

These findings indicate that the education of Aboriginal children cannot be equated with that of European children of the same age or the same period of schooling.

General Activities and Employment

Few Aborigines are employed in skilled or permanent positions. Apart from some of the stockmen on pastoral properties, and some of the Aborigines trained on the missions, they are generally employed in casual unskilled positions on missions or settlements, or remain unemployed. A large proportion of the adult population have not received any schooling, and few have received any special training.

Contact with the European has led to some breakdown of the traditional Aboriginal culture and beliefs, but there is evidence that such beliefs still persist, and in many cases still exert a strong influence on the people, and customs and rituals such as the initiation ceremony are still carried out. While some still engage in traditional hunting and gathering activities, these are becoming less important and more intermittent as they are supplied with cooked meals or rations, clothes, and tobacco on the settlements, missions and pastoral properties. It is therefore probable that their hunting skills are gradually being lost.

3. Environmental Background of the Children Tested

1. Hermannsburg

The mission at Hermannsburg was established in 1877. It is situated in semi-desert country on the banks of the Finke River, which flows only after good rains. The people of this area are mainly from the Aranda tribe. Other tribes represented at Hermannsburg are the Loritja, and the Pitjantjara. These tribes have been extensively studied by the early anthropologists (Spencer and Gillen [1927], Basedow [1925]). The Aranda language was recorded by one of the early Lutheran missionaries, Carl Strehlow, and T.G.H. Strehlow has continued the study of the Aranda language, myths and traditions (Strehlow [1944], [1947]).

The total population on the mission at 30 July 1963 was 502, of whom 48 per cent were children under 16 years of age (figures quoted from Watts and Gallacher [1964]).

Activities on the Mission

Vegetable gardening and cattle were introduced in the early development of Hermannsburg, and have remained the main activities on the mission. Attempts have been made to enable the Aborigines to acquire and herd their own cattle, but these have been largely unsuccessful. A tanning industry was established in 1936, and produces leather goods from kangaroo and bullock hides. A small number of Aborigines are employed in this industry. The cattle industry also employs a few Aborigines, although recent drought conditions have restricted this industry. Other Aborigines are employed in essential activities on the mission; in the vegetable gardens, the bakery, the kitchem (where meals are prepared for the school children), in cleaning and hygiene activities and in collecting firewood. A small number of women are employed in domestic activities and in sewing work, for which they are paid by piece rates. Several women are also employed in the hospital.

A number of Hermannsburg Aborigines are water-colour artists. This art form was started by Albert Namatjira, who learned his technique from Rex Batterbee, a visiting artist. Namatjira's success has popularised Aboriginal water-colours, and a ready market is found for them in the tourist trade. Other tourist objects and curios are also made - decorated boomerangs, spears, wooden carvings, bead necklaces and so on.

Games and Leisure Activities

Since the everyday activities of the people are relevant to an assessment of their environmental background, and to the question of the extent to which operational thinking is required or expressed in their culture, a brief description of the most common leisure activities observed will be given.

While a number of Aborigines are employed on the mission, a greater number remain idle. These people appeared to spend much of their time sitting in the shade in small groups of men or women and talking. The women often played a simple game of tossing a cotton reel.

The object of the game was to make the cotton reel stand upright. Points were marked by each participant by strokes on the ground, and the participant scoring the greatest number of points was the winner. The men played a game called 'nine sticks', which appeared to be an elaborated version of naughts and crosses. It is possible that this was European-introduced, since it was said to be similar to a German game, the early Lutheran missionaries being mainly German. Card games such as poker were said to be played by the men in the camp, but since this was discouraged by the mission authorities it could not be confirmed. Card-playing was certainly known to be popular on neighbouring government settlements and pastoral properties. Observation of a poker game played on a pastoral property in this area indicated that the rules of poker were correctly followed, although the betting system appeared to be rather simple. Poker was played by both men and women on this property, and was very popular.

The children's games were very simple. One game was the 'bucking bronco', where one boy climbed on the back of another who attempted to unseat him by a realistic imitation of a bucking horse. This game was inspired by a rodeo which had recently been held on the mission. A game of 'cars' or 'trains' was played by boys from about three years up to fifteen years or over. In this game one or more empty tins were attached by wire to a long wire handle, and this was pushed around the mission. In some cases up to 13 tins were attached together. This game was apparently one which recurred periodically. As it became less popular, a few girls were observed playing with the trains, presumably abandoned by their owners.

The most popular activity of the girls appeared to be telling 'sand stories'. This was done by drawing figures in the sand by means of a long wire, each figure having a conventional meaning, and the girl accompanying the drawing by a verbal narration. These 'sand stories' are concerned mainly with everyday activities in the camp and with hunting, and have been described in greater detail by Munn.[1]

During a certain season, lasting about a week, the girls on the mission went collecting lizard eggs after school. The younger children (about five to six years) usually accompanied an older child, and were apparently learning the skill from the older children. The lizard eggs were located by markings on the soil where the lizard had covered up its hole. Open holes indicated that the lizard was still in the hole, and these were not disturbed, but were marked for future reference. A special procedure was adopted in digging for the eggs. After the surface soil had been removed, the tunnel of soft soil indicating the path followed by the lizard was located, and this was followed until the eggs were found. This hunting was carried on for pleasure, and the eggs were collected as trophies.

The boys did not take part in hunting lizard eggs, but engaged in other hunting activities. It was known that they knew how to find a particular kind of frog in

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1 The Walbiri Sand Story (Unpublished report).

the dry river bed, and occasionally they would bring lizards or other animals they had found to the school.

Sport was encouraged by the mission and both the adults and the children participated. The men took part in football games and teams were selected to play those from neighbouring settlements. Athletics were organised by the school and competitions were held.

Housing, Health, and Nutrition

Until recently the majority of Aboriginals at Hermannsburg lived in 'humpies' constructed of whatever materials were available, mainly scrap iron. A building programme in early 1964 has established a number of two-roomed aluminium houses which now house most of the Aborigines, although a number still live in humpies. Furniture and utensils in these houses are limited.

The hospital at Hermannsburg has been long established, and the nursing staff are known and trusted by the people. Consequently they are not reluctant to seek treatment at the hospital, as is often found in the newer settlements. The main health problems listed by Tatz (1964) at Hermannsburg are ear infections, sugar diabetes and high blood pressure, chronic nephritis in women, and a high incidence of tuberculosis.

The ration scales for Hermannsburg are shown by Tatz (1964) to be close to the recommended scales, and of a higher standard than that found on other settlements and missions. The babies' diets are supplemented by milk and feeding supplied at the hospital. The school children are served three full cooked meals a day.

Education

School activities at Hermannsburg go back to 1880, when the first school classes were held in the church building. A special school building was completed in 1896. Schooling was initially conducted in Aranda, and later partly in Aranda and partly in English, and the main subjects were religion, reading, writing and arithmetic. From the 1930s onward English became the more important, and finally the sole language of instruction, and the curriculum was widened.[1]

In the early days the teaching was carried out on a part-time basis by the mission staff, and the school equipment was limited. In 1946 Beckenham (1948) reported that there was a total of 69 children at the school under one teacher, and that the school had no special equipment. The staff was gradually increased in the 1950s, and in 1964 there were five full-time teachers, and pre-school classes on a part-time basis were run by a member of the mission staff. In 1963 there were 137 children attending the school (Watts and Gallacher [1964] p.34). The teachers are assisted by Aboriginal teaching assistants, who are untrained.

In recent years the school equipment has been greatly improved and increased. A wide variety of activity materials are in use in the younger classes. There is a workshop containing tools for carpentry and craftwork classes, and regular art and craft classes are

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1 Information on the early history of the school was supplied by T.G.H. Strehlow.

held where the children engage in constructive work. Sewing classes are also held for the girls.

Film sessions are held regularly in the evenings and attended by all the people on the mission. Various adult classes and activities are also organised.

Conclusion

Owing to their long contact with the Lutheran missionaries, and the relatively easy access to Alice Springs, the Aborigines at Hermannsburg have had a closer contact with the European culture than most other groups. Many of the older Aborigines have received education and training on the mission. Hermannsburg has frequently been visited by research teams, tourists, and other visitors, and during the Second World War there was extensive contact with the army personnel stationed in the Alice Springs area. The mission pays the workers in cash and has established a cash store where the Aborigines can buy at will. A second hand clothes shop has also been established. This, in addition to their contacts with Alice Springs and the tourists, has probably led to a greater understanding by the Hermannsburg people of Western values and culture than is achieved by most other groups of Aborigines.

2. Elcho Island

Historical Background

Elcho Island Mission was established by the Methodist Overseas Mission in 1942. The Methodist Mission had previously established a mission at Milingimbi, approximately 50 miles from Elcho, in 1922, and the people in the Elcho area had had some contact with this mission. Some Aborigines from Milingimbi also came to settle at Elcho when the mission was established, so that the influence of the mission in this area goes back some 20 years before this date.

The people of the north-east Arnhem Land coast have a long history of contact with outside traders. Trade with Malays and Macassans goes back several hundred years. While it is not certain when this trade first commenced, the Berndts (1954) state that tentative calculations would place it in the early Sixteenth Century. The traders sailed to Arnhem Land with the seasonal winds, and stayed about six months before returning to their homelands.

In spite of this long contact, the Malay and Macassan traders apparently had little influence on Aboriginal traditional life or culture. No changes were made in the way of life, housing, or traditional systems of exchange. Warner (1958) points out that although the Aborigines traded pearl, pearl shell, tortoise shell, trepang and sandal wood for dug-out canoes, rice, molasses, tobacco, cloth, knives, tomahawks, gin, and pipes, this did not affect their traditional system of exchange based on ritual and social relationship, and the system of exchange among the coastal Aborigines is no different from that of the interior tribes who had no contact at all with the Malay traders.

Warner lists the dug-out canoe with its mast and sail, the Malay type of pipe, and iron and other metals, as the only material contribution made by the Malay traders to the Aboriginal culture, and he points out that this contribution was limited to a small area. He states that their contribution to Aboriginal social life was even less. A Pidgin Malay language was developed and spoken by a number of the coastal natives, and this, together with the dug-out canoes, stimulated greater intertribal contact among the Aborigines themselves. While Warner discounts the importance of this effect, it would seem to be quite a significant influence. There is also said to be some slight influence of the Malays on the local myths and burial customs.

Warner attributes this minimal influence to the fact that the Malays came only to trade, and did not engage in any form of agriculture or attempt to change Aboriginal social customs or beliefs in any way. He also states that there was very little racial mixture between the Malays and Aborigines, due to the policy of the Malay traders of preventing their crews from having any contact with the Aboriginal women to avoid trouble. This view is disputed by the Berndts (1954), who state that the Malay traders took Aboriginal women as temporary wives during their stay in Arnhem Land. The fact that after such a long period of contact there is little evidence of Malay features or colour among the Aboriginal people of this area would tend to support Warner's view. There is however some evidence of Malay mixture, and the head of one of the most prominent families at present living at Elcho Island is said to be part-Malay.

None of the Malay traders remained in Arnhem Land, but a number of Aboriginal men are said to have gone with the Malays to Macassar and other islands in the area, returning to Arnhem Land with the next expedition south.

This trade ended at the beginning of this century, and the Malays were followed by European and Japanese traders. The Berndts (1954) state that the relations between these traders and the Aborigines were poor, mainly because the traders preferred to collect their own goods, which was resented by the Aborigines, and because of incidents involving Aboriginal women. This trade finally ended with the outbreak of war with the Japanese in 1941.

During the war the Aborigines came into fairly close contact with the military bases established in Arnhem Land. They were employed in various capacities and received in return money and other goods. According to the Berndts, it was this contact which finally led to the breakdown of Aboriginal tribal life and economy.

At the end of the war a new pattern of Aboriginal life emerged. The Aborigines had come to depend on the European for food and other goods, and settled around the mission stations. Small groups still lived out in the bush, and hunted and collected food in the traditional manner, but these groups would return periodically to the mission stations, and each visit tended to last longer and longer. At the present time there are probably few groups who do not reside more or less permanently near one of the missions in this area, or on the outstations which are visited regularly by light plane and supplied with rations.

Present Conditions

Elcho Island is situated approximately 330 air miles north-east of Darwin. It is accessible only by air or sea. Few Aborigines have the opportunity of visiting Darwin. Usually only those requiring medical treatment use the air service. The Aboriginal crew of the mission boat are the only people having any regular contact with Darwin.

At 30 July 1963 the population at Elcho was 579, of whom 51 per cent were children under 16 years of age (figures quoted from Watts and Gallacher [1964]).

Activities

The main activities on the mission are agriculture, fishing and sawmilling. Most of the younger adult men are employed in these activities, and are paid contract rates. Men are also employed in building activities and in the machine workshop. Craftwork is engaged in, the Aborigines painting barks and making spears, didgeridoos and other artefacts which are sold through the mission.

Hunting and food gathering activities are still commonly engaged in, particularly by the women. When not at school the children also frequently go hunting, food-gathering, or fishing. The boys prepare lines and hooks for fishing, while the girls collect shellfish. The sea and the beach provide a common ground for leisure activities and swimming, and the boys have canoes.

Around the mission the young children were usually observed sitting in the sand and digging with sticks, stones, or tins. They were also observed playing with old disused pieces of machinery lying about the mission. A form of hide-and-seek was sometimes played by the older children. In general, the games and occupations of the children seemed to be very simple and based mainly on learning hunting and food-gathering skills.

The men were said to bet on card games in the camp. This was discouraged by the mission authorities, and could not be confirmed.

Polygamy is still practised in this area. This system results in the older men having several wives and the younger men having none. This is the source of most of the problems and the fights in the camp, and it is said that family troubles frequently result in the neglect of the children.

Housing

In 1964 the majority of the Aborigines at Elcho lived in small, one-roomed houses. These houses usually have only rough wooden benches and tables. A few stretcher beds were seen. The most common possessions seemed to be blankets and tin mugs. The houses appeared on the whole to be rather dark and to have poor ventilation, and some would be rather overcrowded, particularly since a large group of Aborigines had recently come into the mission from the bush and there was therefore a shortage of housing. Some more primitive houses of scrap iron and other materials had been constructed by the people themselves, and a number of the Aborigines slept in the open around fires. A new housing programme was under construction in 1964, and some of these houses were already occupied. These were larger two and three roomed houses, with adequate lighting and ventilation, each house having separate washing facilities.

Health and Nutrition

The health of the Aborigines at Elcho appeared to be generally poor. The health problems listed by Tatz (1964) for this mission are anaemia, hookworm, diarrhoea, leprosy, and tuberculosis. Eye and ear infections were also common. A check for hookworm in 1964 indicated that approximately 98 per cent of the population were infected.

Workers are issued with a weekly food ration. Tatz (1964) has indicated that this ration falls short of recommended ration scales in quantity and quality. These rations are expected to be supplemented by hunting and food-gathering by the Aborigines. The children are given one cooked meal a day and rations for the other meals. Discussions with the mission staff suggested that the children did not necessarily get the benefit of these rations. A serious problem was considered by some of the staff members to be infant feeding, and the low rate of weight gain by the babies. It was said that while extra milk rations were available for babies who failed to gain weight satisfactorily, frequently the mothers did not bring them regularly to the clinic to receive these extra rations. It was also said that mothers persisted in feeding their babies with black tea, often to stop them from crying, despite constant advice against this practice. This resulted in babies refusing milk and other food when it was given to them because they were full of tea, and the mothers argued that this showed that they were not hungry and did not need the milk.

The health and the nutrition of the Aboriginal children here therefore appeared to be poor. Evidence suggests that such factors may influence mental development (Biesheuval [1943]), and these factors are therefore relevant to a consideration of the results of the present investigation.

Education

The school at Elcho was established by 1950. Up to 1960 the school had only one teacher and up to 90 pupils. Under these conditions teaching was very difficult, and in 1959 the number of children attending school was reduced. It is understood that a number of the older boys who were difficult in school, and a number of those who were not progressing well, were allowed to leave.

From 1960 the teaching staff was gradually increased, and in 1964 there were four full-time teachers. A pre-school was established in 1963 under a trained pre-school teacher. Prior to this a member of the mission staff had taken on a pre-school class on a part-time basis. The teachers are assisted by untrained Aboriginal teaching assistants.

The teaching equipment has been improved in recent years. In 1961 the Cuissenaire teaching materials were introduced in the pre-school class. The school building is small and facilities are cramped. Compared with Hermannsburg the range of school equipment appeared to be more limited, and there were no special facilities for art or craftwork.

Evening classes were run for the non-school children and the adults. For the children these classes mainly took the form of organised games. Films were shown regularly and attended by all the people on the mission.

4. Intellectual Capacity of the Aborigines

The first psychological tests on Aborigines were carried out in 1898 by the Cambridge Anthropological Expedition to the Torres Straits Islands. Despite this early start, little has since been achieved in the scientific psychological study of the Aborigine.

All the psychological studies so far reported on the Aborigines have been based on sensory, motor and perceptual tests, or on traditional methods of intelligence testing. The essential weaknesses of traditional intelligence tests for cross-cultural studies of intellectual development have been discussed in Chapter I. The failure of these studies to provide any real understanding of the intellectual capacities and abilities of Aborigines support the view that such tests are unsuitable for this purpose.

In general, the findings of the various studies reported indicate that while the sensory, motor, and perceptual skills of the Aborigines are comparable to those of Europeans, their performance on tests of mental ability are consistently inferior.

The best known of these studies is that of Porteus (1931) who visited North West and Central Australia in 1929 and carried out a series of psycho-physical and mental tests.

On the psycho-physical tests, Porteus found that the Aborigines' performance was generally poorer than that of Europeans, but he related this difference to differences in stature and weight.

On the mental tests, he found consistently poor performances, with the average mental ages of Aboriginal adult males ranging from about five years to about twelve years. The tests he applied were the Porteus maze test (Av. M.A. - 10.97 years, Av. I.Q. - 80), the Porteus form and assembly test (Av. M.A. - 9.15 years, Av. I.Q. - 60), the Goddard form board (Av. M.A. - 8.17 years), Rote memory test (repetition of digits) (Av. M.A. - 5.38 years), and the Zylophone test (a test of auditory and visual memory adapted from the Knox cube test) (Av. M.A. - 7.88 years). He also devised a test based on matching footprints from photographs, in which he found that the Aborigines' performance was almost equal to that of a group of 14 year old European boys. Finally, he applied a dot estimation test, where the subject was required to order a series of 17 cards according to the density of the dots on the cards, the number of dots increasing from 5 to 85 in increase steps of 5 dots. He found that the Aborigines made an average of about 14 errors, compared with an average of 3.81

errors for Europeans and 4.46 errors for a group of Europeans, Chinese and Japanese. The Aborigines' performance was approximately equal to that of a group of 10 year old children.

Porteus took the view that his findings were evidence of racial differences in intelligence. He put particular emphasis on the importance of rote memory as an indication of educability, and explained the Aborigines' poor performance on this test as due to a mental disability in rote memory. But the unsuitability of this test can be judged from his statement: 'Though very many of my subjects were unable to count beyond five they were at least familiar with the names of the numbers' (Porteus [1931] p.384). He recognised that failure on this test may be associated with unfamiliarity with the number names, and he devised an alternative test based on ability to reproduce familiar syllables. Whie he was unable to complete testing all the subjects on this test, he reported that performances were generally equally poor with syllables as with digits. He gave no figures on these results.

Piaget's studies of seriation throw some further light on Porteus' dot estimation test. While Porteus considered this test as depending purely on estimation of mass, Piaget's studies have indicated that the ordering of a series is itself dependent on a system of concrete operations. The Aborigines' failure on this test could therefore be due either to a failure to discriminate mass, or to lack of the operations necessary for serial ordering. Porteus' test does not distinguish between these two factors. This test illustrates the confounding that can occur in traditional intelligence tests which are not based on an adequate investigation of what the test actually measures, or an adequate theory of what intelligence is.

Porteus also tested a small group of women and a group of children, the children being tested on the Goodenough Draw-a-man test as well as the other tests. He found that the women's performances were generally poorer than the men's, and the children's performances were markedly better, the average I.Qs. of the children varying from 94 on the Porteus Form Assembly test to 55 on the rote memory test. Average I.Qs. on the Draw-a-man test in different groups varied from 69 to 83, and this test was judged to be particularly suitable for application to Aboriginal children. He explains these better performances mainly in terms of increased familiarity with pictures and drawings in the schools. He also points out that about half the children tested were part-blood Aborigines.

Fry and Pulleine (1931) also carried out a series of motor, sensory, and mental tests on Aborigines. They found performance on motor tests generally lower than European norms, but within the normal range. Sensory tests showed no great divergence from European norms, but they reported that visual acuity was much greater than in Europeans, while estimation of weight tended to be poor. Mental tests showed inferior performances, but they point to the difficulties of comparing these results with European performances, and refer to the complex social organisation and the ingenuity of the Aborigines in solving problems in their own social and cultural context as evidence of their mental abilities.

Fowler (1940) tried out four tests, the Passalong test, the Ferguson form board, the Cube construction, and the Kohs Blocks test, on a small group of Aboriginals. He reported that the first three tests were found suitable, but the Kohs Blocks test took too long to administer and was too difficult for the Aborigines. He found average M.As. of 12.75 on the Passalong test and 11.5 on the Ferguson form board. However, he emphasised the wide range of individual scores found on each test, and suggested that previous results reported in terms of average mental ages were misleading, since some Aborigines obtained scores comparable to whites. From this he concluded that their mental capacity was not necessarily inferior to whites and that many of them could benefit from education and training. He tested both males and females, and found no significant differences between the sexes.

At present a test of general cognitive capacity applicable to Australian Aborigines and the indigenes of Papua and New Guinea is being developed at Queensland University under Professor McElwain. No results on this work have yet been published.

References to the intellectual capacities of Aborigines have been made by anthropologists. In general, they have tended to emphasise their complex social structures and kinship systems as evidence of superior mental capacity. However, Levy-Bruhl has argured that these systems appear complex to us because we try to conceive them abstractly, while the primitive never thinks of such relationships abstractly, but only in relation to particular persons whose relationships he has learned and known from childhood. Such relationships therefore present no more difficulty to them than learning, for example, to speak their native language, whose complex rules and structures they may be completely unaware of. Levy-Bruhl's view would seem to be supported by Meggitt's reference to an ambiguity he found in a kinship classification. He states:

> I cannot see, however, how this rule operates for two 'M.M.B.D.S.' who are also reciprocal 'F.F.Sr.S.S.', for their fathers must be cross-cousins. The people themselves could not clarify the matter for me; they simply asserted that a particular man was 'numbana' to the other's 'gandia' because the two had always called each other by these titles[1] (Meggitt [1962] p.161) (M-Mother, B-Brother, D-Daughter, S-Son, F-Father, and Sr-Sister).

With regard to Aboriginal mental capacity Elkin (Foreword to McCarthy [1962]) states:

> Those of us, however, who have gained an insight into their language, social organisation, ritual, religion and philosophy, realize that the Aborigines' intellectual powers are of no mean order. They are logical and systematic in their thinking.

Until such time as 'logical' and 'systematic' are precisely defined, and agreement is reached as to what forms of behaviour are to be classified as logical and systematic, and how such forms are to be defined and

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1 My underlining.

measured, such statements are inadequate for a psychological discussion of the intellectual capacities of Aborigines.

In conclusion, it may be stated that intelligence tests applied to Aborigines have not led to any real understanding of intellectual capacities or development in Aborigines, nor is there any prospect of such tests doing so on their present theoretical basis. Our knowledge of the intellectual development and capacities of the Aborigines up to the present time is extremely limited.

5. Characteristics of Aboriginal Languages

Aboriginal languages are characterised by a wealth of specific concrete terms and a lack of abstract and collective terms. There are no terms for numbers exceeding four or five, and comparative terms are generally lacking.

Strehlow (1944) states that the Aranda language has three degrees of comparison; the positive, comparative and superlative. However, he points out that the superlative may often be used to mean 'very' or 'too', and is therefore not strictly applied. Our own experience in translating and interpreting the tests would suggest that these degrees of comparison are not often used in normal conversation, and the most common method of translating, for example, 'more' was the term used for 'big'.

Strehlow states that there are few conjunctions in the Aranda language. There are some copulative conjunctions, but disjunctive conjunctions such as 'either...or' are entirely absent. He suggests that this characteristic may be due to the Aranda preference for short sentences using participles as connectives rather than conjunctions, and that this form is more suitable for a simple spoken language which prefers short sentences. However, it could also be related to an absence of the operational structures on which concepts of disjunction or conjunction must be based.

Aranda has terms for one and two, and the terms for three, four and five are obtained by combining these terms. There are also terms for many and few. Carl Strehlow recorded terms for five, ten, twenty, thirty, and forty, but Strehlow states that these terms indicated only approximate values and were seldom used.

The usual method of counting in Aranda was to mark off the number on the fingers and toes. Even when a number term was used, the fingers of the hand were usually put up at the same time. This method was feasible up to about twenty. Another method referred to by Strehlow was to mark off the number by parallel strokes on the ground, saying at the same time 'here is one, here is another,...here is the last'. This method was often used in telling stories.

Strehlow states that for all practical purposes counting stops short at five. He says that education has not been able to achieve very much in the teaching of arithmetic, and that the only problems which can be mastered to any degree are those of direct practical concern; for example, counting sheep or cattle, or converting pence to shillings and shillings to pounds. He suggests that this is due to the fact that number was of no importance in the Aboriginal environment. Since they had no herds or crops there was no need to count or compare quantities. Game was usually sighted singly or in twos or threes, and if there were larger numbers there would be no opportunity to count them before they disappeared. Numerals were therefore only necessary for the first few visually grasped numbers, and no abstract system of counting was required or developed.

Elkin (1958) has pointed to the difficulty that is found in teaching children to compare amounts and sizes. He states that while they may be able to arrange objects in piles and see which is the bigger pile, the idea that one is bigger than the other is meaningless. He states that in their own languages comparison is expressed by juxtaposition, and does not make use of a comparative conjunction.

He also points out that no concepts of units of measurement or length have been developed. He states that this is because there is no need for these concepts in the Aboriginal culture. For example, distance is calculated in terms of the number of camps or water sources between places, which will determine how many days it will take to go from one place to another. The length of a spear is determined by the particular materials available, and there is no need to estimate or to compare lengths exactly. In the case of division, Elkin points out that Aborigines do not give or share things by exact division and measurement, but according to the particular part of the animal or the type of food or goods, and on the basis of rules of social obligation and kinship.

Certain characteristics of the local languages were also revealed in our translation of the tests and the children's responses. It was found, for example, that there were no words to express area or volume, and that these concepts could only be expressed with reference to concrete situations. Comparison usually had to be expressed by asking the children which quantity was 'lots', or which stick was 'long'. A few children understood the terms 'more' and 'longer', but in most cases the comparative was expressed simply by saying 'this one has lots' or 'this one is long'.

The alternative 'or' was not understood by the children, and questions could not be asked in this form. Each question had to be put separately. If two alternatives were included in the same question, the children usually answered the second alternative only. It was understood that this difficulty was characteristic of the people as a whole.

It was also noted that the children had difficulty with specific terms, and tended to generalise these terms to inappropriate situations. For example, in the test on weight, which followed that on length, a number of the children tended to use the term 'length' (which had been introduced in the previous test) to refer to weight. Thus they might explain that two bags were the same weight 'because they are the same length'.

One difficulty was found in translating the test on length. In this case it was found that the word 'same' when used to ask if the sticks were the same length was also used to mean 'together' in the sense that the sticks were placed parallel and with their ends coinciding. However, our Aboriginal informant said that if the question was posed so as to emphasise the movement of the stick, and then to ask if the sticks were the same length, the distinction between these two uses of the term would be made clear.

The parallel between this terminology and the development of the concept of length proposed by Piaget is striking. While the terminology in itself is not sufficient to conclude that the Aborigines do not dissociate length in terms of the interval between the end points from the relative positions of the end-points, it does suggest that this distinction is not important in the Aboriginal culture, and that this terminology may reflect either an earlier stage when this distinction was not made, or the present thinking habits of the people. A parallel terminology was found in the words 'different' and 'separate', which are also both translated by the same word. In the test on area it was found that some children referred to the houses in a line as 'the same' (i.e., together), while some children referred to the scattered houses as 'different' (i.e., separate).

Another confusion was found between the terms 'lots' and 'full'. While each of these words were translated by different terms, it was noted that the interpreter tended to use the word for 'full' when she was translating the question 'Which glass has lots of sugar?'. This was particularly marked in the case of the long thin glass, and indicates a clear tendency to refer to quantity in terms of the level. (The use of this incorrect term was always corrected by the experimenter, but it should be noted that an interpreter was only used in the supplementary testing, and that none of the subjects included in the main study were tested through an interpreter.)

CHAPTER V

PROCEDURES

General Plan of the Study

The field research undertaken in this study can be divided into four main phases:

1. Preliminary testing with European children.
2. A pilot study undertaken at Hermannsburg Mission (October 1963).
3. Preliminary testing undertaken at Milingimbi Mission (June 1964).
4. The main study.
   This was divided into two parts:
   a) Testing at Elcho Island Mission (June - August 1964).
   b) Testing at Hermannsburg Mission (September - November 1964).
5. Supplementary testing.

Testing of unschooled children and adults was undertaken at Elcho Island Mission and at Willowra Station, a pastoral property in Central Australia, north-west of Alice Springs.

Aims of Each Phase

1. The preliminary testing of European children provided the basis on which provisional testing procedures were drawn up for the pilot study.
2. The aim of the pilot study was to determine whether the tests selected and the procedures adopted were suitable for application to Aboriginal children. The

selection of tests for the main study, the standardisation of procedures and questioning, and the design of score sheets, was based on the findings of this study.

3. The purpose of the preliminary testing at Milingimbi was to determine whether the procedures drawn up for the main study were suitable, and to effect any changes or modifications in the tests that seemed necessary.

4. The testing of school children at Elcho and Hermannsburg constituted the main study.

5. The additional testing of unschooled children and adults was intended to provide some indication of the possible effects of schooling on the development of the concepts studied. The small number of unschooled children available, and the difficulties of testing these children and adults through an interpreter, precluded the inclusion of these results in the main study. The findings of this additional testing are reported in Appendix 4, and will be referred to briefly in the final discussion.

Only the main study will be considered in the following section. The findings of the pilot study, and the reasons for the selection and the modification of the tests used in the main study are given in Appendix 3, together with the findings of the preliminary testing at Milingimbi.

The study will be considered under the following headings:

1. Selection and Translation of the Tests.
2. Selection of the Sample.
3. General Testing Conditions.
4. Method.
5. Test Procedures.
6. Order of Presentation.
7. Classification of Responses.

1. Selection and Translation of the Tests

Selection

Following the pilot study it was decided to restrict the study to the investigation of the development of the concept of conservation. The main reasons for this were as follows:

1. Piaget maintains that no logical operations are possible in any field before the child has understood that the materials with which he is dealing remain constant regardless of changes in form or sub-division. The concept of conservation is therefore basic to all logical thinking, and has been extensively studied both by Piaget and by other investigators. It would therefore seem appropriate to start the study of conceptual thinking in Aboriginal children with this basic concept.

2. While the development of some concepts, such as those of number and measurement, could depend on whether or not these concepts are developed in the culture, the concept of conservation would be expected to develop as a result of the child's interaction with his basic physical environment, the essentials of which are common to all societies.

3. Piaget and Inhelder have placed some importance on their finding that conservation of quantity, weight and volume are always developed in this order, and on this basis they have suggested that their techniques could provide a natural ordinal scale by which intellectual development could be measured. In the light of this it is important to establish whether or not the same order of development is found in children from a different culture.

Translation

Because of the possibility that differences in language could have influenced the child's ability to understand the problems presented and the terms used, it was decided to have the tests translated into the local language before undertaking the testing.

The purposes of this translation were as follows:

1. To determine whether the terms and concepts used in the tests could be expressed in the local language.

2. To help to determine whether any particular difficulties experienced by the children or any particular characteristics of their responses or explanations could be related to their language.

3. To enable the experimenter to use the native terms in cases where the child did not appear to understand the English terms.

4. To enable the experimenter to keep a better check if an interpreter was necessary for any of the younger children. (In fact, no children included in the main

study were tested with an interpreter. Initially a few seven year old children at Elcho were tested but these children were not included in the study.)

5. In addition to the school children to be tested for the main study, it was intended to test some unschooled children and adults, for whom an interpreter would be necessary.

For the Elcho group, the tests were translated into the local language by the linguist stationed at Milingimbi. The translation was carried out in consultation with an Aboriginal teaching assistant and with the writer. In general it was found that while precise comparative terms were lacking, the questions could be posed in the language, and, according to the Aboriginal teaching assistant, would be understood as intended.

For the Hermannsburg group, the tests for the pilot study were translated into Aranda by an Aboriginal translator on the mission, who was a trained evangelist and who gave religious instruction at the school. For the main study, the further translations were done in consultation with a senior girl at the school, and any problems which arose were checked with the superintendent of the mission, who was familiar with the language. This method was not as satisfactory as that adopted in the case of the Elcho group, but was the best arrangement that could be made. On the whole, it was found that the questions could be posed satisfactorily in the Aboriginal language and would be understood as intended.

2. Selection of the Sample

1. Elcho Group

The children were selected at random from the school registers. Initially it was hoped to test ten children in each age group, but it was not possible to get ten children for the older age groups. Where possible, equal numbers of boys and girls were selected at each age. Children from eight to fourteen years were selected. Dates of birth from the mission records were available in all cases. There were no fifteen year old children at the school. Some seven year old children and some non-school children were also tested, but these results were not included in the main study.

The school was divided into three classes, each under one teacher who was assisted by Aboriginal teaching assistants.

The first class comprised Grades 1 and 2, and the children in this class were aged from seven to eight years.

The second class comprised Grade 3 only, and contained children from nine to fourteen years. It was sub-divided into Grades 3C and 3D.

Promotion to the third class was on the basis of ability. This class consisted of the following groups:

Grade 3 B, Grade 3 A, Grade 3 S.A.[1], Grade 4 S.A. Grade 6 S.A.

After the children were selected, the teachers were asked to rate each child on a 3-point scale; Above Average (AA), Average (A), and Below Average (BA). The teachers were also asked if they thought the children selected were a representative sample of each age group. In the case of the eight year old group, the teacher remarked that the two brightest children of this age had not been selected. Since we were interested in testing as wide a range of abilities at each age as possible, it was decided to add these two children to the sample.

Particulars of the children tested are shown in Appendix 2, Tables 1-3.

2. <u>Hermannsburg Group</u>

Children from eight to fifteen years were selected. Twelve eight-year old children were selected at random from the school register. Since it was not possible to obtain ten children for every age group over eight years, and since few age groups had more than about twelve or thirteen children, it was decided to test all the children from nine years onward at the school. A few children whose dates of birth were not available were not tested, and also some children who were not present at the start of the testing programme. Several children

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1 S.A. indicates that these groups were taking the South Australian Correspondence School courses.

left the school after starting the testing programme. Two children did all but one of the tests. The results of those children who did not complete all the tests are not included in the statistical analyses of the results. Dates of birth were available from the mission records. In the case of two children included in the sample it was discovered later that the dates of birth shown in the school registers were estimates only, since these two children had only recently come to the mission. These children were not excluded from the study since it was thought that an error of perhaps one year could not make any difference to the results. In all other cases the dates of birth were considered to be accurate.

The school was divided into four classes, each class under one teacher, assisted by Aboriginal teaching assistants. This excludes Grade 1 and the pre-school class, which were accommodated in a separate building.

The classes were as follows:

Grade 2	-	divided into Upper and Lower.
Grade 3	-	divided into Upper and Lower.
Grade 4 Grade 5	)	These grades were divided into different groups for different subjects, according to ability and progress.

The teachers were asked to rate the children on a 3-point scale as in the case of the Elcho group.

Particulars of the children selected are shown in Appendix 2, Tables 4-7. Only the children completing all the tests are included.

In Tables 8 and 9 of Appendix 2 the average ages and the average number of years schooling for the Elcho and Hermannsburg groups are shown.

Comments on Tables

From Table 8 it can be seen that the average age for each age group is approximately the same in the two groups.

From Table 9 it can be seen that the Hermannsburg group has an advantage in the average number of years schooling for each age group. This advantage is fairly slight up to 12 years, being rather more marked in the 10 year old group, but for the 13 and 14 year old groups the advantage is over 1 and over 2 years.

In Grade classifications, the Grade 2 classification would be approximately equivalent in the two groups, the Elcho Grade 3 C/D classification would probably correspond to the Hermannsburg Grade 3, while the Elcho Grade 3 A and B classifications would probably correspond to the Hermannsburg Grade 4 classification. The Elcho S.A. groups would probably correspond most closely with the Hermannsburg Grade 5 group.

From Table 7 it can be seen that in most cases the Hermannsburg part-blood children have a high proportion of Aboriginal ancestry. There is no difference in the environmental background or schooling of the part-blood and full-blood children.

3. Testing Conditions

The testing room was determined by the facilities available. At Elcho, the children were tested in a small store-room. At Hermannsburg, they were tested in the staff room in the school building. While the conditions were more cramped at Elcho, this seemed unlikely to influence the results.

The child was seated at a table, and the test materials were set out in front of him. His answers were recorded on score sheets. A sample of tape recordings for each test were taken. These served as examples and also acted as checks on the questioning in each test.

Testing Sessions

The children were tested during normal school hours. Each session lasted from about 5 to 15 or 20 minutes, depending on the test and the subject. The average time was about 10 to 15 minutes.

Each test was administered in a separate session. In the Elcho group the time between each session for each child was normally about one week. In the Hermannsburg group the interval was about 10 to 14 days. The interval was longer in the Hermannsburg group because of the larger sample, and also because it was sometimes necessary to cut short the testing in the afternoons because of craftwork and sporting activities which the children did not like to miss.

4. Method

The method followed in the presentation of the tests was based on Piaget's clinical method. The essence of this method is to present a question or a problem to the child, and then to allow him to talk freely in his answers or attempts to solve the problem. The initial question is then followed up by further questions designed to clarify or to check the child's answers. This method allows a fuller investigation of the child's thought processes than would be possible with a standardised method.

The flexibility of this method was considered essential for the present investigation, since the children came from a different cultural and linguistic background, and it was necessary to vary and to rephrase the questions in case of possible misunderstandings or communication difficulties, and to check the reliability of the children's answers. The use of this method also ensured the comparability of the results obtained with those reported by Piaget for European children.

A degree of standardisation has been introduced in some studies in Geneva and by other investigators such as Laurendau and Pinard (1962) and Smedslund (1959). In the present case it was done by first presenting each problem to all children in exactly the same way, and then rephrasing the questions where any misunderstanding was suspected or where clarification was required. Counter-suggestions, a regular feature of Piaget's method, were frequently put to the child to check the stability of his answers, and the questions were often repeated several times and in several different ways to check the consistency of his responses.

5. Test Procedures

All the test situations are illustrated in Appendix 1.

1. Quantity

A. Materials

2 standard glasses, A and A'; 1 long, narrow glass, L; 1 wide glass, W; 4 small glasses, Cs. Quantity of sugar. 2 black dolls.

B. Problem

Introduction

After some preliminary questioning on the materials (e.g., What is this called? [Sugar] What are these here? [Dolls]) the child was told that sugar was to be given to the two dolls to eat. The sugar was poured into the glasses A and A'. Initially unequal quantities were poured into the two glasses, and the child was asked the standard questions (see below). This procedure was designed to determine whether the children understood the problem and the terminology used, and were able to answer the questions correctly.

Part 1. Equal quantities were poured into A and A', and the standard questions, as below, were asked. If necessary, the quantities were adjusted until the child judged them to be equal.

Part 2. The sugar from A' was poured into L, and the child was questioned as indicated below. The sugar from L was then returned to A', and Part 1 was repeated.

Part 3. The sugar was poured from A' into W, and the child questioned as in Part 2. The sugar was then returned to A' and Part 1 was repeated.

Part 4. The sugar was poured from A' into the C glasses, and the child questioned as for Part 2.

Variations in Procedure

If the children showed immediate and firm conservation, the repetition of Part 1 between Parts 2 and 3, and Parts 3 and 4, was sometimes excluded. In such cases Part 4 was usually presented before Part 3, since pouring the sugar directly from the wide glass to the small glasses was a difficult operation, while pouring from L to Cs and from Cs to W was easy and quicker.

Questioning

The following standard questions were asked for each situation:

Q1. Is the sugar in the two glasses the same?

Q2. Does one glass (or doll) have more (or lots of) sugar? (If 'yes') Which one has more?

(Q2 was asked regardless of the answer to Q1. This was found necessary since some children tended to answer 'yes' to all questions.)

The following supplementary questions were asked in Parts 2, 3 and 4:

S1. Will the two dolls have the same sugar to eat?

S2. Does one doll have more (or lots of) sugar to eat? (If 'yes') Which one has more to eat?

The child was asked for an explanation for each judgement in Parts 2, 3 and 4. The basic 'why' questions were as follows:

W1. Why do you think..........?

W2. How do you know...........?

Where children did not give an explanation immediately, these questions were repeated and reformulated in various ways. The child was often encouraged by saying: 'Go on, just tell me what you think', or similar phrases.

Variations in Questioning

1. If children appeared to be answering 'yes' to all questions, the child was asked first if one glass had more sugar, and then if the other glass had more sugar. It was noted that some children answered 'yes' to both these questions, suggesting randomness of answers. Some children would answer 'yes' to one of these questions and 'no' to the other, but also answered 'yes' to Q1. (These inconsistencies were classified as non-conservation or transitional according to the overall pattern of responses, see discussion on classification, p.198-201.)

2. A number of children were questioned in Parts 2, 3 and 4 as to whether the sugar would be the same if it was put back into A'.

3. Questions were frequently repeated, particularly with children who were giving inconsistent answers or appeared to be answering at random.

4. Children who showed consistent conservation were offered counter-suggestions to check the stability of their conservation. For example, they would be asked: 'Do you think this one has more because it is higher here?' or 'But look, this one has lots of glasses. Do you think he has more sugar too?'. (All children classified as conservation consistently resisted such suggestions, see discussion on classification.)

2. Weight

A. Materials

1 balance scale + weights.
2 medium sized plastic bags, A and A'; 1 long, narrow plastic bag, L; 1 large plastic bag, W; 6 small plastic bags, Bs. A quantity of tea leaf.

B. Problem

Introduction

The working of the scale was demonstrated to the children with equal and unequal weights placed in each pan. The children were then shown two weights and asked to predict if the two weights would make the scale 'stay the same' or 'stay level', or if one weight would make the scale 'go down', and if so, which. In each case they were asked to give a reason for their prediction. Their prediction was then checked on the scale, and the children were questioned on each demonstration (e.g., Why does the scale stay the same? Why does this one make the scale go down?). If the children answered that it was because one weight was 'bigger' or the weights were 'same', he was told: 'Because they are the same heavy' or 'Because this one is heavy (very heavy, heavier)', the emphasis being placed on the heaviness of the weights in each case.

Part 1. Tea leaf was then weighed out on the scale into the plastic bags A and A'. The child verified that the scale was 'level', and that the tea leaf in the two bags was 'the same heavy'. The bags were then taken off the scale and the standard questions Q1 and Q2 were asked (see below).

Part 2. The tea leaf from bag A' was poured into bag W, and the child was questioned as indicated below. The tea leaf from W was then put back into A' and the standard questions Q1 and Q2 were repeated. If the child did not judge the tea leaf to be the same in A and A', the weights were again checked on the scale, but normally this was not necessary.

Part 3. The tea leaf from bag A' was poured into bag L, and the child questioned as in Part 2. The tea leaf from L was then poured back into A', and the same procedure followed as in Part 2.

Part 4. The tea leaf from bag A' was poured into the B bags, and the child questioned as in Part 2.

Variations in Procedure

1. If the children showed immediate and firm conservation, the return of the tea leaf to bag A' at the end of each part of the test was sometimes excluded.

2. A variation was introduced in Part 4 by removing some of the small bags and asking the child to compare 1, 2, 3, 4 or 5 small bags of tea leaf with bag A. This provided a useful check where the children's responses were doubtful or inconsistent, but it was not necessarily applied in all cases.

Questioning

The standard question Q1 and Q2 followed the same pattern as in the case of Quantity, i.e.,

Q1. Is the tea leaf in the two bags the same heavy?

Q2. Is one bag of tea leaf heavier (very heavy)? (If 'yes') Which is heavier?

The following supplementary questions were asked in Parts 2, 3 and 4.

S1. If we put this bag of tea leaf on this side of the scale, and this bag of tea leaf on this side of the scale (indicating), would the scale stay the same (stay level)?

S2. Or do you think one bag would make the scale go down? (If 'yes') Which one would make the scale go down?

The child was asked for an explanation for each judgement in Parts 2, 3 and 4. The 'why' questions followed the same pattern as in the case of Quantity.

Variations in Questioning

Variations in questioning and additional questions followed the same pattern as in the case of Quantity. The standard questions were normally repeated after the supplementary questions in each case.

3. Volume

A. Materials

2 identical glasses, about 1/3 filled with coloured water. Plasticine balls - 2 yellow balls of the same size; 1 large red ball; 1 small brown ball.

B. Problem

Introduction

The child was asked if the level of the water in the two glasses was the same, and if the large red ball and the small brown ball were the same size, or which one was bigger.

Small brown ball

Prediction: The child was asked to predict what would happen if the brown ball was put into the glass of water. If he did not answer, or did not understand the question, he was asked if he thought the water would stay at the same level, or if it would 'come up higher'.

Demonstration: The brown ball was then put into the glass of water, and the child was asked if the water 'stayed the same' or 'came up'. (If the child maintained that the water stayed the same, the procedure was repeated and the child was told to 'watch very carefully', and he was then questioned as before.)

Large red ball

Prediction: As for brown ball.
In addition, the child was asked if the red ball would make the water come up 'the same high' as for the brown ball, or higher. He was asked for an explanation for this prediction.

Demonstration: As for brown ball.
The same additional questioning as in the case of the prediction was put to the child, but referring to the actual situation demonstrated.

Finally, the child was asked why the water came up when the plasticine was put inside the glasses. The plasticine balls were then removed from the glasses of water.

Part 1. The child was again asked if the level of the water in the two glasses was the same, and was then asked if the two yellow plasticine balls were the same size. The plasticine balls were adjusted if necessary until the child agreed that they were the same. The child was then asked the standard questions (see below). If he did not answer correctly, the balls were placed in the glasses of water to demonstrate that the water would come up to the same level. (This was in fact not necessary for any of the children tested.)

Part 2. One ball was flattened, and the child was questioned as indicated below. The plasticine was then formed back into a ball, and Part 1 was repeated.

Part 3. One ball was rolled into a long sausage, and the child was questioned as in Part 2. The plasticine was then formed back into a ball, and Part 1 was repeated.

Part 4. One ball was broken into a lot of little pieces, and the child was questioned as in Part 2.

Variations in Procedure

1. The repetition of Part 1 between Parts 2 and 3, and Parts 3 and 4, was excluded with some subjects who showed immediate and firm conservation.

2. In many cases, Part 1 was supplemented by asking the child to predict whether the yellow and the brown ball would make the water rise to the same level, or which would make the water rise higher, and whether the red and the yellow ball would make the water rise to the same level, or which would make the water rise higher.

Questions

The following standard questions were asked:

Q1. If we put this plasticine into this glass, and this plasticine into this glass (indicating), do you think that the water will come up the same high in the two glasses?

Q2. Or do you thing that one lot of plasticine will make the water come higher? (If 'yes') Which plasticine will make the water come higher?

The following supplementary questions were asked:

S1. Do you think this plasticine is the same size as this plasticine?

S2. Do you think that one lot of plasticine is bigger? (If 'yes') Which is bigger?

S3. Do you think there is the same amount of plasticine in this ball and in this plasticine here (flat, long, pieces)?

S4. Do you think that one of these has more plasticine? (If 'yes') Which one has more plasticine?

The child was asked for an explanation for each judgement in Parts 2, 3 and 4. The 'why' questions were the same as in the case of Quantity and Weight.

For Q1, the motion of lifting the plasticine and placing it in the glass was indicated, or the plasticine was held up over the glass in which it was supposed to be placed. Where there appeared to be doubt as to whether the plasticine would fit into the glass, for example, in the case of the long plasticine, the child was told: 'We'll twist it up like this (demonstrating) so that <u>all</u> the plasticine will go into the glass. We'll put it so that the plasticine goes right into the water'.

<u>Drawings</u>

Following this procedure, the child was presented with a series of drawings showing the glasses and the

plasticine (see figure opposite). After some introductory remarks (e.g., Do you like to draw? We are going to make some drawings of the plasticine in the water), the child was presented with the first sketch, showing the two glasses with the level of the water drawn in, next to each of which was a sketch showing the large ball and the small ball inside a glass, but without the level of the water drawn in. The large and the small ball were placed next to the glasses, and the child was asked the standard questions (see below). If the child failed to understand what was required, he was encouraged in various ways. If he drew the line at exactly the same level as the sketch showing the glass without the plasticine inside, he was asked if the water would come up higher when the plasticine was inside the glass, and if that was what he had shown in his sketch. He was then allowed to have another try. If he did not succeed, the balls were placed inside the glasses and the child was asked to draw the level of water as he could see it.

Part 1. The child was then presented with the second sketch, showing the glasses with the two equal-sized balls placed inside, but without the level of the water drawn in, next to sketches of the glasses showing only the level of water without the plasticine. The procedure was repeated as in the case of the Introduction.

Part 2. One ball was flattened, and the child was presented with the third sketch showing the round ball in one glass and the flattened ball in the other glass. Questions D1, D2, and D3 were asked (see below).

Part 3. The flattened ball was lengthened, and the child was presented with the fourth sketch showing the round ball in one glass and the long plasticine in the other glass. Questions D1, D2 and D3 were repeated as in Part 2.

Part 4. The long plasticine was broken into little pieces, and the child was presented with the fifth sketch showing the round ball in one glass and the pieces in the other glass. Questions D1, D2 and D3 were repeated as in Part 2.

Standard Questions for Drawings

D1. Look, here are the glasses with the water inside (indicating). This sketch (indicating) shows this ball inside the glass here, and this sketch shows this one (long, flat, pieces) inside this glass here (indicating from plasticine and glass to sketch). I want you to draw the line to show me where the water will come to when we put this plasticine inside this glass here, and this plasticine inside this glass here.

When the child had drawn in the level for both glasses he was asked:

D2. Does the water come up the same high in the two glasses? (If 'no') Which one comes up higher?

If the verbal statement conflicted with the drawing the child was asked:

D3. Is that what you have shown in your drawing?

If the child said 'no', he was asked to correct his drawing to show where the water would come.

4. Length

A. Materials

Pipe cleaners cut into various lengths, including 2 of equal length (about 7 cms. long) and one curved in a zig-zag fashion.

B. Problem

(For positions of sticks in all situations see Figure A.)

Introduction

Two pipe cleaner sticks of unequal length were placed in front of the child, and the child was asked the standard questions Q1 and Q2. Two sticks of equal length were then placed in front of the child, and the child was again asked questions Q1 and Q2 (see below).

Part I. i) The child was presented with a straight stick and a curved stick placed in such a way that the ends of the two sticks coincided and was then asked standard questions Q1, Q2 and Q3.

ii) If the child judged the sticks to be of equal length, and to be the 'same far' and to take the 'same time to walk', the curved stick was then straightened, so that its ends overlapped those of the straight stick, and the standard questions were repeated. It was then put back to its original form and the questions repeated.

iii) If the child judged that the curved stick was longer in the original position, or that it was 'longer to walk' or 'takes longer time to walk', the curved stick was adjusted so that both ends were overlapped by the ends of the straight stick. The standard questions were then repeated.

Part II. i) Two sticks of equal length were presented in a position horizontal to the child, parallel and with the end points coinciding (see Figure A). The standard questions were put to the child. The top stick was then pushed from right to left so that its left end point overlapped that of the bottom stick by about 1 to 2 cms. (all positions refer to the child's point of view). The standard questions were then repeated. If the child judged one stick to be longer, the sticks were returned to their original positions and the whole of this procedure was repeated.

ii) The sticks were then placed in various positions (see Figure A) and the standard questions Q1 and Q2 were repeated.

iii) Finally the sticks were again placed parallel and with the end points coinciding, and the questions Q1 and Q2 were repeated. The procedure was then repeated as in i).

Questions

The following standard questions were asked:

Q1. Are these two sticks the same length?

Q2. Is one stick longer? (If 'yes') Which stick is longer?

Q3. If one little ant walked along this stick from here to here (indicating), and another little ant walked along this stick from here to here (indicating), would the two ants:

i) a) Have the same distance (same far) to walk?

b) Would one ant have further (longer) to walk? (If 'yes') Which ant would have further (longer) to walk?

ii) a) Would the two ants take the same time to walk?

b) Would one ant take a longer time to walk? (If 'yes') Which one would take longer time?

Supplementary Questions

i) Would one ant have shorter to walk? (If 'yes') Which...?

ii) Would it be quicker to walk from here to here, or from here to here (indicating)? (If 'yes') Which is quicker?

iii) If the two ants started at the same time, this one started here and this one started here (indicating), would they both arrive here and here (indicating) at the same time?

Variations in Questioning

1. When children showed immediate and firm conservation, the questioning was reduced so that not all questions were asked for every situation, but all questions were asked in at least one situation.

2. Supplementary questions were asked where necessary to clarify the child's answers or reasoning.

Why Questions

The child was asked for an explanation for all his judgements in Parts I and II. The 'why' questions followed the same form as in the case of the other tests.

5. Area

A. Materials

2 toy cows. Rectangular and square sheets of green cardboard of varying sizes, including 2 of equal size. Small blocks of wood.

B. Problem

Introduction

It was first explained to the child that the green paper represented green grass, and the cows were to be put into paddocks of green grass to eat. All the children knew what cows were, and that they ate grass. They had no difficulty in understanding that when the field of grass was bigger, there would be more grass for the cow to eat.

A. The cows were first put into paddocks of unequal size, and the standard questions Q1 and Q2 were asked.

B. The cows were then put into paddocks of equal size, and the standard questions were repeated.

C. It was explained to the child that the wooden blocks represented houses which were to be built in the fields. One house was placed in one field, and it was pointed out that where the house stood there was no grass for the cow to eat, because the house covered up the grass. The standard questions were then put to the child.

D. If the child did not understand that the paddock with the house had less grass for the cow to eat, a number of houses were placed in one field, emphasising that where the houses stood there was no grass for the cow to eat, and the standard questions were repeated. The number of houses were then gradually reduced and the standard questions were repeated. If after this procedure the child still did not understand that the paddock with one house had less grass for the cow to eat, the test was discontinued.

E. When the child had understood that the paddock with one house had less grass for the cow to eat, one house was added to the second field and the standard questions were repeated.

General Procedure

1. One house was then added to each field simultaneously, these being placed together in a row in one field, and scattered at random on the other field. The standard questions were asked after each pair of houses was added.

2. Houses were added until:

i) The child judged that one paddock had more grass for the cow to eat.

ii) The child judged that the amount of grass in the two paddocks was the same up to 12 or 14 houses.

The test was then varied according to the child's reactions.

i) Where the child judged one field to have more grass, houses were in some cases added to that field until the child reversed his judgement. Houses were then added to the other field until the child again reversed his judgement, and the test was continued with this procedure for a while. In other cases the test was discontinued after one or two more houses had been added, either to one field only, or to both simultaneously, and non-conservation was clearly established.

ii) Where the child judged the two fields to have the same amount of grass up to 12 or 14 houses, 2 houses were added first to one field and then to the other, and the child asked the standard questions.

Note. Where the number of houses on the two fields was unequal, the child was always questioned first on the number of houses in the two fields. If he answered this incorrectly he was asked to count the houses until he could say correctly which field had more houses.

The test was discontinued when either conservation or non-conservation was clearly established. In i) the test was in some cases continued for some time to determine the point at which the child would reverse his judgement.

Standard Questions

The following standard questions were asked:

Q1. Do the cows have the same amount of green grass to eat? (Or - Is the grass in the two fields the same for the cows to eat?)

Q2. Does one cow have more (lots of) green grass to eat? (If 'yes') Which cow has more (lots of) green grass to eat?

Supplementary Questions

The following supplementary questions were asked:

S1. Is the number of houses in the two fields the same?

S2. Are there more (lots of) houses in one field? (If 'yes') Which field has more (lots of) houses?

Emphasis was placed in questioning on the fact that the cows had all the grass in the two fields to eat. The cows were often moved around the fields and in between the scattered houses, pointing out that the cow could eat all the grass in the fields. The questions on the number of houses were related to the standard questions by repeating the standard questions after the questions on the number of houses, starting 'And so, do you think....'

Why Questions

The child was asked for an explanation for each judgement, the 'why' questions following the same form as in the previous tests.

6. Number

A. Materials

Small blocks of wood, 1" square. Pieces of paper as bases for building the houses: two pieces 3" x 4", one piece 2" x 2", one piece 3" x 2", one piece 2" x 6".

B. Problem

Introduction

The 3" x 4" papers were put out, and it was explained that these papers would be used as a base for 'building houses'. The child was asked to build a house identical to that of the experimenter, following the experimenter's every step. The experimenter then started building a house, putting down three blocks at a time in rows. The child followed each step. The house was built three rows high. Once the houses were built the remaining blocks were put away, and the child's attention was drawn to the fact that these blocks were no longer needed, and that there were no blocks left on the table other than those in the houses.

Part 1. The standard questions were put to the child (see below).

Part 2. The experimenter then broke down her own house, and explained that she was going to use another base to build another house, using exactly the same blocks as she had had before. The 3" x 2" base was used. When this house was built the child was asked the standard questions. This house was then broken down and the original house was rebuilt, and Part 1 was repeated.

<u>Part 3</u>. The original house was again broken down and the 2" x 2" base was used to build another house. The standard questions were then put to the child. This house was then broken down again and the original house put up, and Part 1 was repeated.

<u>Part 4</u>. The original house was again broken down and the 2" x 6" base was used to build another house. This house was the same height as the original. The standard questions were put to the child.

<u>Note</u>. After each reconstruction it was pointed out to the child that all the blocks had been used in the new house, and that no blocks were left over. The child was asked to confirm this in each case (i.e., Have we used <u>all</u> the blocks from the other house? Are there any blocks left over?).

<u>Variations in Procedure</u>

Where children showed clear and immediate conservation, Part 1 was not repeated after Parts 2 and 3.

<u>Standard Questions</u>

The following standard questions were put to the children:

Q1. Are the houses the same size?

Q2. Is one house bigger? (If 'yes') Which is bigger?

Q3. Are there the same number of little blocks in the two houses?

Q4. Does one house have more (lots of) little blocks? (If 'yes') Which house has more (lots of) blocks?

Why Questions

The child was asked for an explanation for each judgement, the 'why' questions taking the same form as in the previous tests.

Variations in Test Procedures

The following were the main variations which were adopted in presenting the tests.

1. Children who were very shy or who would not give any explanations were constantly encouraged and the questions constantly repeated. If they appeared not to understand the problem the initial introduction was repeated and varied in different ways in an effort to enable them to understand. While answers were never judged as correct or incorrect, it was sometimes found that children could be encouraged by saying 'That's right' or 'That's good' to whatever answer they finally gave. Usually the experimenter's response to the child's answers was 'I see', or no response at all was made.

2. A few children showed strong reactions with the repetition of questions, and after the first few questions often refused to answer any more questions. In such cases the questions asked were reduced to a minimum to try and get a few responses for each situation.

3. Where an unusual or unexpected response was given, this was usually followed up with further questioning. It was found most profitable to do this when the child was particularly confident and co-operative. There was usually no point in putting further questions to shy and reluctant children, because this tended to confuse them and to lead them to make random answers.

4. Questions were reduced with children who showed immediate conservation with an adequate explanation. These children often showed impatience with the repetition of questions.

6. Order of Presentation

It was decided to present the tests in a standard order to all the children. This procedure was adopted for the following reasons:

1. The main aim of the study was to investigate the development with age of the concepts studied. Since a standard order of presentation gives greater 'precision' of results, as defined by Lindquist (1953), it was considered most appropriate for the comparison of results from child to child, from age to age, and from test to test.

2. It was desired to compare the children's responses over all the tests to determine whether any consistent patterns of response were occurring in all the children, and whether the development of conservation in the areas studied followed a consistent order of development. If the order of presentation had been varied from child to child, the children's patterns of response would not

have been comparable, and inconsistencies due to different orders of presentation may have masked other consistent tendencies.

3. Convenience of testing favoured a standard order of presentation for the following reasons:

a) It simplified the organisation of the testing situation, the score sheets and the test materials.
b) It made it easier to maintain a consistent pattern of questioning, to evaluate each child's response in relation to other children's responses on the same test, to pick out unusual answers, to follow up promising lines of questioning suggested by one child's response with subsequent children, and to concentrate on the problems of one test at a time.

The order of presentation for the five main tests was as follows:
Quantity, Length, Weight, Area, Volume.

The tests on length and area were placed between those on quantity, weight and volume in order to reduce the possible effects of perseveration in those tests where the basic situations were very similar.

Order Effects

Order effects would be expected to occur in the present situation, in which the tests would initially be quite new and unfamiliar to the children.

For a series of six tests, an adequate study of order effects would require at least six groups of children at each age level. Since only a limited number of children were available, this was clearly impractical.

It was therefore decided not to jeopardize the main purpose, which was to study the development of conservation from age to age and the relationship between the children's performances on all the tests, by undertaking an inevitably unsatisfactory study of order effects.

To get some indication of whether order effects would be as marked as expected for this group of children, the test on number was added at the end of the series for the Elcho group and at the beginning of the series for the Hermannsburg group. The findings in this connection are reported in Chapter VI.

The whole problem of order effects will be considered in the final discussion of the results.

7. Classification of Responses

The children's responses on each of the tests were classified into three stages of development. These were:

I. Non-conservation.
II. Transitional.
III. Conservation.

These three stages correspond to Piaget's main stages of development. The description of these stages and Piaget's corresponding stages of development is shown in Table 1.

TABLE 1

CLASSIFICATION OF RESPONSES

Classification	Description	Piaget's corresponding Stages
I. Non-Conservation	Changes in form or position, or sub-division, is judged to result in a change in quantity, weight, length, area, number and volume.	Number) Stage I Quantity) Weight - Stages I, II Volume - Stages I, II, & III Length) Stages I, IIA Area)
II. Transitional	Both conservation and non-conservation responses given.	Number) Stage II Quantity) Weight - Stage IIIA Volume - Stage IVA Length) Stage IIB Area)
III. Conservation	Quantity, weight, length, area, number and volume is judged to be the same with changes in form or position and with sub-division.	Number) Quantity) Stage III Length) Area) Weight - Stage IIIB Volume - Stage IVB

Discussion of Classification

In his discussion of the classification of answers obtained by the clinical method, Piaget (1929) emphasises that every answer must be considered in its context. He points out that the danger in this method is attributing either the maximum or the minimum value to everything the child says. He states:

> there are certain subjects who inspire confidence right from the beginning, who can be seen to reflect and consider, and there are others of whom one feels equally certain that they pay no heed to the questions and only talk rubbish in their replies (Piaget [1929] p.10).

In assessing the responses of the Aboriginal children it was equally clear that some children were bored and inattentive, and were simply giving random answers, while other children showed interest in the problems and were clearly thinking out their answers.

Piaget distinguished five main types of response. While these were related to his earlier verbal studies, they are also applicable in the present context. These were:

1. Random answers.
2. Romancing.

The child simply invents an answer which he does not really believe.

3. Suggested conviction, including perseveration when the questions are asked in a suggestive series. In this case, the child's answer is suggested by the question, or he simply gives the answer he thinks the examiner wants, without thinking for himself. In this category

would also be included answers which are influenced by conversation with other children.

4. Liberated conviction.

A belief which is formed only when the question is put to the child.

5. Spontaneous conviction.

A belief which the child has already formed.

With the exception of romancing, which was not found in the type of test used in the present study, the same types of reaction were found in Aboriginal children.

Piaget distinguished random answers and suggested convictions from liberated and spontaneous convictions on the basis of:

1. Counter suggestions.
2. Related questions.
3. Rephrasing of questions.

He states that it is difficult to distinguish between a liberated and a spontaneous conviction, since both show the same characteristics and are resistant to suggestion. This distinction can therefore only be made on the basis of observation.

In fact, this distinction is not essential, since both liberated and spontaneous convictions indicate the child's genuine beliefs and therefore his particular level of development. Both are distinguished by the same criteria that distinguish genuine beliefs from non-genuine beliefs. These are:

1. They show a continuous evolution, with an intermediate stage of development, and traces of

the earlier convictions are found together with the first correct responses.

2. They are related to a number of similar beliefs.
3. There is a uniformity in the answers of children of about the same age, and certain responses show a progressive decrease with age rather than being suddenly abandoned.

In the classification of the three stages of development, Piaget's methods were used for distinguishing between genuine and non-genuine responses. This distinction was probably more difficult to make in the case of Aboriginal children, since these children seldom made spontaneous comments during the test and were usually unable to expand or clarify their explanations. The observations on which this distinction could be made were therefore more limited. However, in practice, it was usually quite easy to distinguish between these responses.

As these stages mark a gradual process of development, the line dividing one stage from the next is not always clear; some children necessarily fall somewhere between two stages, and must be classified in one or another. The procedure adopted in all cases of doubt was to place the child in the more advanced stage of development.

Summary of Classification of Responses

The main distinction between Non-conservation and Conservation responses was in most cases clear, and the classification of Conservation cases was in all but a very few cases made with complete confidence.

The distinction between Non-conservation and Transitional cases was not always so clear, and there may be some overlap between these classifications.

The distinction between Transitional and Conservation cases was usually clear, and any overlap that occurred between these stages is probably relatively unimportant, since any child wrongly classified as Conservation instead of Transitional would have been very close to reaching the level of Conservation.

Since in cases of doubt the children were always placed in the higher stage of development, any errors in classification would tend to favour the children and the results would tend to be biassed toward showing a higher level of development rather than the reverse.

CHAPTER VI

RESULTS

The results will be discussed under two main headings.

I. General Results.

II. Analysis of Results.

I. General Results

The number of children at each age level classified at the three stages of development on each of the tests is shown in Tables 2 and 3.

The classification of the children according to their performance over all the tests is shown in Table 4.

The percentage of children at each age level showing conservation of quantity, weight, volume, length, area and number in the Elcho and Hermannsburg groups is shown in Figures 1 to 6.

The total percentage of children showing conservation on each of the tests in the Elcho and Hermannsburg groups is shown in Figure 7.

In Figures 1 to 6 it can be seen that there is a general tendency for conservation to be achieved with increasing age. This does not show a smooth progression, and there are distinct differences between the Elcho and Hermannsburg groups.

In the Elcho group the 50 per cent conservation level (i.e., 50 per cent or more children show conservation) is generally achieved at 12 years. In the

TABLE 2

NUMBER OF CHILDREN CLASSIFIED AT NON-CONSERVATION TRANSITIONAL AND CONSERVATION STAGES ON EACH TEST

ELCHO GROUP (N=65)

Tests and Stages	Age Groups							
	8yrs N=12	9yrs N=10	10yrs N=10	11yrs N=10	12yrs N=10	13yrs N=8	14yrs N=5	Total N=65
Quantity								
I	9	8	4	3	-	1	-	25
II	3	2	5	4	3	3	2	22
III	-	-	1	3	7	4	3	18
Weight								
I	10	3	8	2	1	1	1	26
II	2	6	-	2	1	2	-	13
III	-	1	2	6	8	5	4	26
Volume								
I	12	9	8	5	2	4	2	42
II	-	1	1	1	2	-	1	6
III	-	-	1	4	6	4	2	17
Length								
I	7	5	7	6	2	2	2	31
II	3	2	-	-	3	1	1	10
III	2	3	3	4	5	5	2	24
Area								
I	12	8	8	6	3	6	2	45
II	-	2	2	1	2	1	1	9
III	-	-	-	3	5	1	2	11
Number								
I	9	4	4	4	3	1	1	26
II	2	4	3	1	1	1	1	13
III	1	2	3	5	6	6	3	26

Stages

I = Non-conservation
II = Transitional
III = Conservation

TABLE 3

NUMBER OF CHILDREN CLASSIFIED AT NON-CONSERVATION TRANSITIONAL AND CONSERVATION STAGES ON EACH TEST HERMANNSBURG GROUP (N=80)

Tests and Stages	Age Groups								
	8yrs N=12	9yrs N=9	10yrs N=11	11yrs N=10	12yrs N=9	13yrs N=10	14yrs N=7	15yrs N=12	Total N=80
Quantity									
I	9	5	7	5	5	1	3	2	37
II	2	3	-	3	-	5	1	4	18
III	1	1	4	2	4	4	3	6	25
Weight									
I	8	3	2	3	2	1	3	4	26
II	1	3	1	1	1	3	-	-	10
III	3	3	8	6	6	6	4	8	44
Volume									
I	11	5	8	7	6	6	3	4	50
II	-	3	2	1	3	3	2	5	19
III	1	1	1	2	-	1	2	3	11
Length									
I	7	3	4	4	4	1	3	2	28
II	1	-	1	1	3	4	-	5	15
III	4	6	6	5	2	5	4	5	37
Area									
I	12	5	8	8	7	8	3	7	58
II	-	1	2	1	-	1	2	-	7
III	-	3	1	1	2	1	2	5	15
Number									
I	10	9	8	8	4	7	5	5	56
II	1	-	2	-	3	1	-	2	9
III	1	-	1	2	2	2	2	5	15

Stages

I Non-conservation
II Transitional
III = Conservation

TABLE 4

CLASSIFICATION OF CHILDREN ACCORDING TO PERFORMANCE OVER ALL THE TESTS

ELCHO GROUP

Age Group	Number	NC	T1	T2	C1	C2
8	12	6	2	4	-	-
9	10	1	4	4	1	-
10	10	1	5	2	2	-
11	10	2	1	3	1	3
12	10	-	1	2	5	2
13	8	-	1	1	6	-
14	5	-	1	1	3	-
Totals	65	10	15	17	18	5

HERMANNSBURG GROUP

Age Group	Number	NC	T1	T2	C1	C2
8	12	6	-	5	1	-
9	9	1	1	5	1	1
10	11	-	2	6	2	1
11	10	1	1	6	1	1
12	9	1	1	5	2	-
13	10	1	-	5	3	1
14	7	1	1	2	1	2
15	12	1	1	5	2	3
Totals	80	12	7	39	13	9

NC = Non-conservation in all cases
T1 = Transitional reactions in one or two cases
T2 = At least one conservation response, or persistent transitional responses
C1 = Conservation in most cases other than area and volume
C2 = Conservation in all cases. (This classification includes a few children who show initial non-conservation on one or two tests, but finally achieve conservation on all later tests including area and volume.)

tests on weight and number this level is achieved at 11 years. This level is not always maintained in the later age groups. Age 11 marks a fairly clear transition point in the Elcho group, with few children below 11 years showing conservation on any of the tests, and an increasing number of children from 11 years achieving conservation.

In the Hermannsburg group there is not such a clear progression with age, particularly in the tests on length and area, where the 9 year old group show performances comparable to those of the 14 and 15 year old age groups.

The 50 per cent conservation level is achieved at 15 years for quantity, 10 years for weight, and 9 years for length. It is not maintained in the 12 and 15 year old age groups in the case of length. This level is not achieved at all for volume, area and number. There is no clear transition point in this group.

The 8 to 10 year old age groups tend to perform better in the Hermannsburg group than in the Elcho group, while the 11 to 14 year old age groups tend to perform better in the Elcho group. In the test on number the performance of the Elcho group is consistently better at all ages over 8 years.

Order of Difficulty of the Tests

The percentage of children achieving conservation on each of the tests is shown in Table 5. The approximate ratios of Elcho to Hermannsburg children achieving conservation on each test is shown in Table 6.

TABLE 5

PERCENTAGE OF CHILDREN ACHIEVING CONSERVATION

Tests	Elcho Group	Hermannsburg Group	
	8-14yrs N=65	8-14yrs N=68	8-15yrs N=80
Weight	40	53	55
Length	36	47	46
Quantity	28	28	31
Volume	26	12	14
Area	17	13	18
Number	40	13	18

TABLE 6

APPROXIMATE RATIO OF CHILDREN IN ELCHO AND HERMANNSBURG GROUPS ACHIEVING CONSERVATION

Tests	Elcho Group	Hermannsburg Group
	8-14yrs N=65	8-14yrs N=68
Weight	1	1.3
Length	1	1.3
Quantity	1	1
Volume	2	1
Area	1.3	1
Number	3	1

The order of difficulty for weight, length, and quantity was the same in the two groups. The order of difficulty for volume and area was reversed in the Hermannsburg group as compared with the Elcho group.

The ratio of children achieving conservation on each of the tests was approximately the same (1:1 to 1:1.3) for the tests of weight, length, quantity, and area. The higher ratio (2:1) in the case of volume suggests that it is the greater difficulty of volume for the Hermansburg group that is the cause of the reversal in the order of difficulty for volume and area in this group.

The relative order of difficulty for the number test was markedly different in the two groups. In the Elcho group, where this test was administered last, this was one of the two easiest tests. In the Hermannsburg group, where this test was administered first, it was one of the three most difficult tests. This test also showed the greatest difference in the ratio of children achieving conservation in the two groups (3:1).

The greatest difference in the relative order of difficulty and in the ratio of children achieving conservation in the two groups was therefore found in the case of number, the only test that was administered in a different relative order in the two groups. These differences were in the expected direction, the children performing better on the test when it was presented last in the series.

In Figure 8 the percentage of children achieving conservation is plotted against the order of presentation. From this figure it can be seen that in both groups there is an improvement in performance with order of presentation from quantity to length and from length to weight, while in both groups there is a marked drop in performance from weight to area. The Elcho group then show a marked improvement from area to volume and from volume to number, while the Hermannsburg group show a further slight drop from area to volume.

These findings indicate that an improvement in performance with order of presentation occurs in some cases but not in all cases.

Differences in Order of Difficulty with Age

The children from 8 to 14 years in both groups were divided into two age groups, from 8 to 10 years, and from 11 to 14 years, and the performance of the younger and older children on each of the tests was compared. This is shown in Table 7.

From this table it can be seen that in the Elcho group the relative order of difficulty for number, quantity, volume and area is the same in both the older and the younger children. There is, however, a difference in the relative difficulty of length and weight. For the younger children length is clearly the easiest test, while a much smaller percentage of children succeed in weight. This order is reversed in the older children, where weight is clearly the easiest test, and length becomes as difficult as volume, one of the most difficult tests of the series.

TABLE 7

ORDER OF DIFFICULTY OF TESTS FOR YOUNGER AND OLDER CHILDREN

Groups	N	Order of Difficulty and Percentage Showing Conservation						
Elcho								
8-10years	32	Order	L	N	W	Q	V	A
		Per cent	25	19	9	3	3	0
11-14years	33	Order	W	N	Q	L	V	A
		Per cent	70	61	52	48	48	33
Total 8-14years	65	Order	W	N	L	Q	V	A
		Per cent	40	40	36	28	26	17
Hermannsburg								
8-10years	32	Order	L	W	Q	A	V	N
		Per cent	50	44	19	16	9	6
11-14years	36	Order	W	L	Q	N	A	V
		Per cent	61	44	36	22	17	14
Total 8-14years	68	Order	W	L	Q	A	N	V
		Per cent	53	47	28	13	13	12

In the Hermannsburg group the reversal between the relative difficulty of weight and length for the older and younger children is not so marked, but is nevertheless quite clear. There is also a reversal in the relative difficulty of number for the older and younger children, this test being the most difficult test for the younger children, while for the older children this test is less difficult than volume and area.

In the Hermannsburg group the differences in performance between the older and younger children are not as marked as in the Elcho group, and the test on area is of approximately equal difficulty for the younger and the older Hermannsburg children. This is a surprising result in view of the difficulty of this test for most of the children. It was noted that the nine year old Hermannsburg group, who did particularly well on length, also did particularly well on area (see Figures 4 and 5), suggesting that there may be some relation between the ability to solve these two problems.

The percentage of younger and older children achieving conservation in each of the tests, plotted against the order of presentation of the tests, is shown in Figures 9 and 10. In both groups a clear difference between the younger and the older children is noted.

In the Elcho group the older children show a slight drop in performance from quantity to length, and a clear rise from length to weight, while the younger children show a marked rise from quantity to length, and a clear drop from length to weight. This pattern suggests that the effect of experience is operating differently on the younger and older children.

In the Hermannsburg group, the same tendency is found, but is not as marked as in the Elcho group. This could be due to the greater overlap of ability between the younger and the older children, particularly between the ages of 9 and 12 years. Both the younger and the older children show an improvement in performance from quantity to length, but this improvement is much more marked in the younger than in the older children. The older children show an improvement in performance from length to weight, but the younger children show a drop in performance from length to weight.

In view of these findings it was decided to determine how many children showed an improvement in performance from test to test according to the order of presentation of the tests, and how many children showed a drop in performance. This is shown in Table 8. All improvements are included in this table; that is, improvements from non-conservation to transitional as well as improvements from non-conservation or transitional to conservation. This table shows clearly that improvement with experience is not occurring uniformly in all children, and that there are clear differences between the younger and the older children on some of the tests. In particular, the performances from quantity to length and from length to weight show marked differences in the number of improvements and drops for the younger and the older age groups.

TABLE 8

TOTAL NUMBER OF IMPROVEMENTS AND DROPS IN PERFORMANCE FROM TEST TO TEST ACCORDING TO ORDER OF PRESENTATION

Groups		Tests					
		N-Q	Q-L	L-W	W-A	A-V	V-N
Elcho 8-10yrs	Imp. Drop	- -	12 6	3 7	- 10	2 2	13 0
11-14yrs	Imp. Drop	- -	4 13	11 1	2 17	9 5	9 3
Total 8-14yrs	Imp. Drop	- -	16 19	14 8	2 27	11 7	22 2
Hermannsburg 8-10yrs	Imp. Drop	9 1	12 2	6 6	3 15	4 4	- -
11-14yrs	Imp. Drop	14 1	10 4	11 5	1 21	7 5	- -
Total 8-14yrs	Imp. Drop	23 2	22 6	17 11	4 36	11 9	- -

Differences between Part-Blood and Full-Blood Children

A comparison was made between the performances of the full-blood and the part-blood children in the Hermannsburg group (see Table 9). The younger and older age groups were compared separately, and a comparison was also made of the combined age groups after four eight-year old full-blood children and four fifteen-year old part-blood children had been excluded from the sample. This exclusion was necessary to balance the number of full-blood and part-blood children at these ages. The children were excluded at random. The number of conservation responses for the children excluded and included in these age groups is indicated in Table 10. In both cases the differences favour the full-blood group.

In all the tests and in both the younger and the older age groups a higher proportion of the part-blood children achieved conservation. A chi-square test of significance was applied to these differences. Yates' correction for continuity was applied where any expected frequency was less than seven.

In the younger age group the differences were significant at the .05 level for the tests on length and number, and approached significance for quantity and weight.

In the older age group the differences were significant at the .01 level for quantity, and at the .05 level for weight and length.

In the combined age groups all the differences were significant or approached significance.

TABLE 9

COMPARISON OF PART-BLOOD AND FULL-BLOOD CHILDREN

1 YOUNGER AGE GROUP 8-11yrs

Test	Number Showing Conservation		X^2	Yates*1 Correction	Significance Level
	Full-blood N=25	Part-blood N=17			
Quantity	2	6	3.279	A	.05<P<.10
Weight	9	11	3.343		.05<P<.10
Volume	0	5	5.778	A	P<.05
Length	10	10	1.437		N.S.
Area	1	4	2.053	A	N.S.
Number	0	4	4.058	A	P<.05

2 OLDER AGE GROUP 12-15yrs

Test	Number Showing Conservation		X^2	Yates*1 Correction	Significance Level
	Full-blood N=17	Part-blood N=21			
Quantity	2	15	13.527		P<.01
Weight	7	17	4.793	A	P<.01
Volume	2	4	.0272	A	N.S.
Length	3	13	5.843	A	P<.05
Area	2	8	2.138	A	N.S.
Number	3	8	1.045	A	N.S.

3 COMBINED AGE GROUPS *2

Test	Number Showing Conservation		X^2	Yates*1 Correction	Significance Level
	Full-blood N=38	Part-blood N=34			
Quantity	4	18	15.214		P<.01
Weight	16	25	7.227		P<.01
Volume	2	8	3.595	A	.05<P<.10
Length	12	20	5.365		P<.05
Area	3	10	4.255	A	P<.05
Number	3	9	3.22	A	.05<P<.10

*1 A indicates Yates Correction applied.

*2 4 - 8 year old full-blood children and 4 - 15 year old part-blood children excluded. See text.

TABLE 10

NUMBER OF CONSERVATION RESPONSES FOR CHILDREN EXCLUDED AND INCLUDED IN THE GROUPS CONCERNED

Group	Number of Conservation Responses	
	Children Included	Children Excluded
8 year old full-bloods	3	1
15 year old part-bloods	10	15

The number and percentage of full-blood and part-blood Hermannsburg children achieving conservation were compared with the Elcho group (see Table 11). In the younger age group the Elcho performances were similar to those of the full-blood children, while in the older age group the Elcho performances were closer to those of the part-blood children. Over the combined ages the Elcho performances were generally intermediate between those of the full-blood and the part-blood children.

No tests of significance were applied to these differences, since the two groups were not directly comparable. In particulr, there were differences between the Elcho and Hermannsburg groups on the tests on number and volume. There were also differences between the performance of the younger and older children in the two groups.

II. Analysis of Results

The technique of scale analysis developed by Guttman is particularly appropriate for the analysis of

COMPARISON OF PART-BLOOD AND FULL-BLOOD HERMANNSBURG CHILDREN WITH FULL-BLOOD ELCHO CHILDREN

1 YOUNGER AGE GROUP 8-11yrs

Tests	Hermannsburg				Elcho	
	Full-blood N=25		Part-blood N-17		Full-blood N=42	
	No	%	No	%	No	%
Quantity	2	8	6	35	4	9.5
Weight	9	36	11	65	9	21
Volume	0	0	5	30	5	12
Length	10	40	10	59	12	28.5
Area	1	4	4	24	3	7
Number	0	0	4	24	11	26

2 OLDER AGE GROUP 12-15yrs

Tests	Hermannsburg				Elcho	
	Full-blood N=17		Part-blood N=21		Full-blood N=23	
	No	%	No	%	No	%
Quantity	2	12	15	71	14	61
Weight	7	41	17	81	17	74
Volume	2	12	4	19	12	52
Length	3	18	13	62	12	52
Area	2	12	8	38	8	35
Number	3	18	8	38	15	65

3 COMBINED AGE GROUPS

Tests	Hermannsburg* 8-15yrs				Elcho 8-14yrs	
	Full-blood N=38		Part-blood N=34		Full-blood N=65	
	No	%	No	%	No	%
Quantity	4	10.5	18	53	18	28
Weight	16	42	25	74	26	40
Volume	2	5	8	24	17	26
Length	12	32	20	59	24	37
Area	3	8	10	29	11	17
Number	3	8	9	26	26	40

* 4 - 8 year old full-blood and 4 - 15 year old part-blood children excluded.

the present results. Guttman's scale analysis is designed to determine whether a given set of items conforms to a uni-dimensional scale, such that any individual who ranks higher than another individual on the same set of items, must also rank just as high or higher on every item in the set than the other individual (Edwards [1957] p.172).

Piaget's theory of stage sequences assumes such a uni-dimensional scale in conceptual development, and Piaget and Inhelder (1962) have postulated an invariant order for the development of conservation of quantity, weight and volume. A number of writers, including Hunt (1961) and Flavell (1963) have suggested the application of Guttman's scale technique to the study of Piaget's stage sequences and the verification of the invariant orders he has postulated. Wohlwill (1960) has discussed the application of the scalogram technique to the determination of developmental sequences. A number of studies in which scale analysis has been applied to the investigation of Piaget's developmental stages have already been reported (Wohlwill [1960], Dodwell [1961], Kofsky [1966] Peel [1959]).

Guttman's methods of scale analysis have been subjected to severe criticisms by Festinger (1947), Loevinger (1948) and others. The main criticisms of his method are based on the fact that his co-efficient of reproducibility does not take into account all the relevant data. His co-efficient is determined on the basis of the following factors:

1. The number of items.
2. The size of the sample.
3. The number of errors. (A number of different methods of calculating the number of errors have been devised.)

Guttman requires a co-efficient of reproducibility of .90 or higher as evidence of scalability. However, he states that reproducibility is not a sufficient test of scalability, and lists four factors which have to be taken into account (Guttman [1950]).

1. The range of marginal distributions.

This will affect the minimal marginal reproducibility of any set of items.

2. The pattern of errors.

If a co-efficient of reproducibility of over .90 is obtained, but if examination of the pattern of errors reveals a 'substantial frequency' of a particular non-scale type, a second variable is presumed to be affecting the responses so that the items studied do not form a uni-dimensional scale.

On the other hand, when the co-efficient of reproducibility is less than .85, but examination of the pattern of errors fails to indicate 'substantial frequencies' for any particular non-scale types, the set of items is said to constitute a 'quasi-scale'. In such a case, Guttman maintains that the scores of the subject are determined by one major variable and a number of minor variables, the major variable largely determining the rank order of the subjects, but the minor variables contributing to the error of reproducibility.

3. The number of items.

Guttman points out that the more items in a scale, the greater the assurance with which the co-efficient of reproducibility may be accepted. He suggests that where only two response categories are scored, at least ten items should be used, but that a lesser number would be acceptable if the marginal frequencies of several of the items are in the range of 30 per cent to 70 per cent. No absolute limits for the number of items are suggested.

4. The number of response categories.

Guttman also points out that the more response categories included, the greater the assurance with which the co-efficient of reproducibility may be accepted. He suggests that where the number of items in the scale is small, as many response categories as possible should be used.

In view of the limitations of Guttman's co-efficient of reproducibility, a number of alternative methods have been suggested for testing the uni-dimensionality of a set of items.

Loevinger (1947) has introduced the concept of homogeneity, and points out that Guttman's definition of a 'scale' applies exactly to homogeneous cumulative tests (Loevinger [1948]). She states:

> In a perfectly homogeneous test, when the items are arranged in the order of increasing difficulty, if any item is known to be passed, the probability is unity of passing all previous items. In a perfectly heterogeneous test, the probability of an individual passing a given item A is the same whether or not he is known already to have passed another item B (Loevinger [1947] p.29).

Loevinger's method of calculating homogeneity (H_t) takes into account all the data, and is a weighted average of probabilities for each pair of items adjusted so that the co-efficient will equal zero for a perfectly heterogeneous test, and unity for a perfectly homogeneous test.

This method has the advantage of making use of all the data, having a fixed maximum and minimum value, and being independent of the number of items used and the distribution of item difficulties. It is applicable only when two categories of scoring are used. The sampling distribution of H_t is unknown, and Loevinger advises that it should not be used as an estimate of homogeneity unless the sample exceeds 100. However, with reference to reproducibility, Willis (1954) suggests that there is no reason to assume that the proportion of error changes according to the size of the sample, so long as N is large in comparison with the number of items.

Loevinger also provides a method of determining a co-efficient of homogeneity between each pair of items (H_{ij}) and a co-efficient of homogeneity between each item and the total test score (H_{it}).

H_{ij} is defined in terms of the probability of scoring plus on a more popular item for those known to have scored plus on a less popular item:

$H_{ij} = 0$ for statistically independent items.

$H_{ij} = 1$ for perfectly homogeneous items.

H_{it} is based on the assumption that in a perfectly homogeneous test, subjects passing a given item should have higher total scores than those failing the item. Loevinger states that $H_{it} = 1$ if all discriminations are correct, and $H_{it} = 0$ if correct discriminations equal wrong discriminations. She points out that no rigorous connection has been established between H_t and H_{it}.

White and Saltz (1957) point out that it is not clear that a zero value for H_{it} is obtained when there is no relation between an item and the total test, and that the sampling properties and consequently the value to be expected for a chance relation are not known. They suggest an alternative method of determining the homogeneity between each item and the total test score derived from the phi co-efficient. This method is based on the assumption that in a perfectly reproducible test, the subjects passing or failing a particular item will be the same subjects discriminated into the same proportionate groupings on the basis of their total score (i.e., if 30 per cent of the children fail a particular item, and if the children are ranked according to total score, the 30 per cent who fail the item should correspond to the lower 30 per cent of children ranked according to total score). This method yields a measure termed ϕ_{it}. White and Saltz state that this measure has the advantages of an absolute maximum of unity and an absolute minimum of zero, a known sampling distribution, and a direct relationship to conventional test procedure. They state that an Index for the test as a whole can be derived by averaging the obtained phi co-efficients. This Index will have a maximum value of 1.00, but the chance value will vary according to the average item difficulties, and will approach .50 as the average item difficulties approach the 50 per cent level. The sampling distribution of this Index is not known.

Jackson (cited by White and Saltz [1957]) has proposed a method of calculating a Plus Percentage Ratio (PPR) for a co-efficient of reproducibility obtained by the Guttman technique. This is calculated by the following formula:

$$\frac{\text{Co-efficient of Reproducibility} - \text{Minimal Marginal Reprod.}}{1 - \text{Minimal Marginal Reproducibility}}$$

White and Saltz point out that this ratio takes account of the minimal marginal reproducibilities, and thus circumvents one of the most serious criticisms of Guttman's reproducibility index. It has the advantage of fixed minimum and maximum values (1 to zero) for any test of more than 1 item. While an acceptable level for this index has not yet been determined, Jackson suggests that the 70 per cent level may be taken to indicate scalability.

Jackson's PPR is similar to the Index of Consistency proposed by Green (1956) for which Green suggests .50 as an acceptable level for scalability. White and Saltz maintain that this would lead to an over-estimate of scalability. Green's method of computing errors is similar to that used by Loevinger, but he compares only those pairs of items adjacent in difficulty, and has therefore only a partial count of errors.

For the present investigation it was decided that Guttman's scalogram analysis had certain unique advantages in the determination and examination of scale and non-scale patterns of response. For this reason Goodenough's (1944) method of scale analysis was applied to the results. In view of the short-comings of the co-efficient of reproducibility obtained by this method, a number of additional analyses were applied to the results. These were:

1. A Plus Percentage Ratio (PPR_G) similar to Jackson's PPR and Green's Index of Consistency, but based on the co-efficient of reproducibility obtained by the Goodenough method of scale analysis (Rep_G). This method yields a more complete count of errors than that used by Jackson or Green, so the PPR_G may be expected to be rather lower than that obtained by Jackson's or Green's method.

The formula for obtaining PPR_G is:

$$PPR_G = \frac{Rep_G - MMR}{1 - MMR}$$

where PPR_G = Plus Percentage Ratio

Rep_G = Co-efficient of reproducibility obtained by the Goodenough method.

MMR = Minimal marginal reproducibility

2. Loevinger's homogeneity test (H_t).

3. Loevinger's inter-item test (H_{ij}).

4. White and Saltz's test for homogeneity between each item and the total test score derived from the phi co-efficient ($\emptyset_{it}$).

Application of the Goodenough Method of Scale Analysis

The Goodenough method of scale analysis as described by Edwards (1957) was applied to the results.

The children were ranked according to their total score over all the tests. Two methods of scoring were used, and separate analyses were carried out for each method.

The two methods of scoring were:

1. Two categories of response scored.
   1 = Conservation
   0 = Transitional or Non-conservation.

2. Three categories of response scored.
   2 = Conservation
   1 = Transitional
   0 = Non-conservation.

A bar chart was drawn up based on the frequencies of each category in each test, and from this the predicted pattern of response corresponding to each total score was determined. The response pattern of each individual was then checked against the expected response pattern for his total score, and each deviation of an observed response from the predicted response was counted as an error. The number of errors thus obtained was summed and divided by the total number of responses (N x no. of items) to give the proportion of error. This figure was then subtracted from 1 to give the co-efficient of reproducibility.

The minimal marginal reproducibility was calculated by summing the model frequencies for each item and dividing by the number of items, and then dividing this figure by N.

Scalogram analyses were carried out for the following series of tests:

1. All the tests in the series i.e., Q.W.V.L.A.N.

2. All the tests excluding length i.e., Q.W.V.A.N.

It was observed that the test on length was relatively easier for the younger children than for the older children, and this test was excluded to determine to what extent this difference was affecting the reproducibility of the scale as a whole.

3. All the tests excluding length and area i.e., Q.W.V.N.

It was observed that some of the tests appeared to be of equivalent difficulty. For example, if a child failed one test only, he might fail either volume or area, and if a child passed one test only, he might pass either length or weight. Theoretical considerations suggested that the tests on length and area may depend on the development of special spatial schemas depending on infra-logical operations and involving the co-ordination of sub-divisions and changes of position, and therefore may not depend on precisely the same schemas of logical operations required for the conservation of quantity, weight, volume, and number.

Thus length and area may not belong to the same scalable 'universe' as quantity, weight, volume and number, although depending on the same basic concrete operational structures.

4. Q.W.V.

Piaget and Inhelder have postulated an invariant order for the conservation of quantity, weight and volume, and a separate scalogram analysis was carried out on these tests to determine whether or not they form a separate uni-dimensional scale.

5. L.A.N.

While conservation of number should depend on the same schemas as conservation of quantity, being merely a particular case of conservation of quantity, it is possible that in this particular case conservation of number may also depend on the same spatial schemas as required for length and area, since in this test the units are formed into three dimensional structures, and the child may need to co-ordinate sub-divisions and changes of position in these constructions in order to conserve the number of units. Thus length, area and number may form a separate uni-dimensional scale.

The results of the scalogram analyses carried out are shown in Table 12, together with the Plus Percentage Ratios and Loevinger's H_t for each series of tests. The item-test relationships are shown in Table 13, and the inter-item relationships are shown in Table 14.

TABLE 12

ANALYSES OF RESULTS

Series of Tests	Goodenough Scale Analysis — Scoring Categories: 3 Categories		2 Categories		Loevinger's H_t
	Rep_G.	P.P.R.$_G$.	Rep_G.	P.P.R.$_G$.	H_t
Elcho Group					
All items	.78	.55	.90	.68	.74
Q.W.V.A.N.	.82	.64	.94	.80	.83
Q.W.V.N.	.82	.67	.94	.82	.83
Q.W.V.	.85	.72	.96	.87	.85
L.A.N.	.82	.62	.92	.74	.68
Hermannsburg Group					
All items	.75	.39	.90	.66	.72
Q.W.V.A.N.	.80	.49	.96	.84	.75
Q.W.V.N.	.83	.60	.97	.89	.84
Q.W.V.	.83	.62	.99	.97	.95
L.A.N.	.80	.46	.97	.89	.61

Rep_G. = Co-efficient of Reproducibility

P.P.R.$_G$. = Plus Percentage Ratio.

Co-efficients of Reproducibility and Plus Percentage Ratios

From Table 12 it can be seen that where three categories of scoring are used, the co-efficients of reproducibility vary from .75 to .85. While these co-efficients do not meet Guttman's criteria for scalability, the figures are high enough to suggest that the tests may form a quasi-scale. Guttman's requirements for scalability are very strict, and are seldom met in practice. Peel (1959) has suggested that in applying Guttman's scaling technique to Piaget's tests, a co-efficient of .75 or higher is sufficient to give strong support to his sequence of stages.

The plus percentage ratios for these co-efficients vary from .55 to .72 in the Elcho group, and from .39 to .62 in the Hermannsburg group. An acceptable level for the plus percentage ratio has not been determined. Green has suggested .50 for his Index of Consistency, while Jackson has suggested .70 as an acceptable level for his PPR. Since the Goodenough method employs a more complete count of errors than Jackson's or Green's methods, we may suggest .60 as an approximate indication of scalability. On this criterion all the sub-divisions of the complete series of tests are scalable in the Elcho group, while in the Hermannsburg group only the items Q.W.V.N. and Q.W.V. are scalable.

When two categories of scoring are used all the series of tests analysed attain a co-efficient of .90 or higher, and are therefore scalable by Guttman's criteria. The plus percentage ratios are in all cases above .60, and in all the sub-series of the complete test are above .80, with one exception in the Elcho group. For the Q.W.V. series an almost perfect scale is attained in the Hermannsburg group. In both groups the Q.W.V.N. and the Q.W.V. series show very high co-efficients of reproducibility and plus percentage ratios, supporting the view that these series may form separate uni-dimensional scales.

The high plus percentage ratios obtained when two categories of scoring only are used indicates that the higher co-efficients of reproducibility for two categories of scoring are not spurious. This suggests that the distinction between conservation and pre-conservation responses may be true to scale, while the distinction between non-conservation and transitional responses are not necessarily true to scale.

<u>Co-efficients of Homogeneity</u>

Loevinger's homogeneity test indicates that the homogeneity of all the series tested is high. All the series except L.A.N. give an H_t of over .70. In the Elcho group there is a marked improvement in homogeneity when the test on length only is excluded from the series, but little further improvement when the tests on area and number are excluded. This indicates that the main source of non-homogeneity in the Elcho group is found in the test on length. In the Hermannsburg group there is only a slight improvement in homogeneity when the test on length is excluded, with more marked improvements when the tests on area and number are excluded. The index of homogeneity reaches .95 for the Q.W.V. series.

This indicates that the sources of non-homogeneity in the Hermannsburg group are found mainly in the tests on length, area, and number.

A comparison of the H_t for the series Q.W.V. and L.A.N. in the two groups suggests that the series Q.W.V. may constitute a uni-dimensional scale, while the series L.A.N. does not.

Item-test Relationships

The item-test relationships are shown in Table 13. In both groups quantity shows the highest ϕ_{it} and length shows the lowest ϕ_{it}. The order of the other item-test relationships is approximately the same in the two groups with the exception of volume, which shows the second highest ϕ_{it} in the Hermannsburg group but the second lowest ϕ_{it} in the Elcho group. For all tests except length the ϕ_{it} approaches .70 and ranges up to .94.

Inter-item Relationships

The inter-item relationships are shown in Table 14. In both groups the QW and WV pairs show high inter-item relationships. The QV relationship is also high in the Hermannsburg group, but intermediate in the Elcho group.

The QL and WL inter-item relationships are low in both groups. The VL relationship shows perfect homogeneity in the Hermannsburg group, but very low homogeneity in the Elcho group.

TABLE 13

ITEM-TEST RELATIONSHIPS

ϕ_{it} (White and Saltz)

Test	ϕ_{it}	
	Elcho	Hermannsburg
Quantity	.92	.94
Weight	.87	.75
Volume	.68	.79
Area	.78	.67
Number	.83	.75
Length	.60	.55
ϕ Index for Total Test	.78	.74

TABLE 14

INTER-ITEM RELATIONSHIPS

H_{ij} (Loevinger)

Items	H_{ij}	
	Elcho	Hermannsburg
Q & W	.85	1.00
Q & V	.66	.82
Q & L	.30	.45
Q & A	1.00	.58
W & V	.84	1.00
W & L	.31	- .33
W & A	.75	.34
V & L	.11	1.00
V & A	.50	.75
L & A	.54	.54
N & Q	.84	.72
N & W	.57	.67
N & V	.75	.49
N & L	.31	.54
N & A	.75	.29

Scale and Non-scale Patterns of Response

The advantage of Guttman's scaling technique is that it permits an examination of the obtained and expected patterns of response for each score. The number of children who deviate from expected scale types, and the type of deviations that occur, can therefore be determined.

An examination of non-scale types of response is also important to the determination of scalability. Guttman states that the co-efficient of reproducibility alone is not sufficient to indicate scalability. Among other factors, the presence or absence of 'substantial frequencies' of particular non-scale patterns of response must be checked before scalability can be asserted (see discussion p.219). Guttman states that if a substantial frequency of a particular non-scale type occurs, this is an indication of non-scalability, even in cases where the co-efficient of reproducibility reaches .90 or higher, since this indicates that the scale is not uni-dimensional. On the other hand, if there is no substantial frequency of a particular non-scale type, this is an indication that total score is determined by one major factor and that the scale is therefore uni-dimensional. If a scale is uni-dimensional, but does not meet Guttman's criterion of reproducibility, it is referred to as a 'quasi-scale'. In both a true scale and a quasi-scale errors are assumed to be random or due to a number of minor variables. If a second major variable is found to be present, the scale is not regarded as uni-dimensional.

The presence or absence of substantial frequencies of particular non-scale types is therefore relevant to Guttman's definition of a scale.

An examination of the non-scale patterns of response was made for the scale analyses of the whole series of tests for two categories of scoring and for three categories of scoring.

1. Two Categories of Scoring

The number of children showing scale and non-scale types where two categories of response were scored is shown in Table 15. The non-scale types are sub-divided according to the number of deviations they contain.[1] The minimum number of deviations for any non-scale type is two. The scale types are divided into those where no deviation is possible (Scores 0 and 6), and those where deviation is possible (Scores 1 - 5). In some cases percentages are given in brackets after the number to facilitate interpretation.

In both groups non-scale types are found in approximately 30 per cent of the children. In all except one case these non-scale types involve only the minimum of two deviations. The only exception was a 13 year old Elcho subject who showed four deviations. This subject was clearly at a transitional stage of development during the testing period, and her non-scale responses are due to the fact that after showing

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[1] The method of determining deviation or error is described on p.225.

TABLE 15

NUMBER OF CHILDREN SHOWING SCALE AND NON-SCALE TYPES OF RESPONSE - TWO CATEGORIES OF SCORING

Groups	No.	Scale Types			Non-Scale Types					
		Scores 0 & 6	Scores 1 - 5	Total	Number of Deviations					Total
					2	3	4	5	6	
Elcho	65	35(54%)	10(15%)	45	19(31%)	-	1	-	-	20
Hermannsburg	80	29(36%)	28(35%)	57	23(29%)	-	-	-	-	23

TABLE 16

FREQUENCY OF REVERSALS BETWEEN PAIRS OF TESTS FOR TWO DEVIATIONS - TWO CATEGORIES OF SCORING

Tests Reversed	Elcho		Hermannsburg	
	Frequency	Score at which reversal occurs	Frequency	Score at which reversal occurs
L/W	6	1	10	1
L/V	3	4 & 5	-	-
V/A	3	5	1	4 & 5
Q/V	2	4	1	4
W/N	2	1	1	1
N/A	1	5	-	-
V/N	1	2	3	4 & 5
L/A	1	5	-	-
Q/L	-	-	4	2
A/W	-	-	2	1
L/N	-	-	1	2

conservation on the first test (quantity), she showed transitional responses on the following two tests (length and weight), and finally achieved conservation on area, volume and number. It may be noted that in this case the test on weight was found to be more difficult than that on quantity, as would be expected by Piaget, but contrary to the general pattern of responses in this particular group.

A larger proportion (54 per cent) of Elcho children showed scores of 0 and 6, where no deviation was possible, and approximately three quarters of the scale types found in the Elcho group are at these scores. In the Hermannsburg group 36 per cent of the children showed scores of 0 and 6, and only half of the scale types found are due to these scores. Comparing the number of scale and non-scale types found from scores 1 to 5 it can be seen that in the Hermannsburg group slightly more scale than non-scale types are found, while in the Elcho group only about one third of the responses are scale types. The high co-efficients of reproducibility obtained are due to the fact that where deviations occur, these are only one off the perfect scale.

An examination of the non-scale patterns of response indicate that there are certain deviations that tend to occur more frequently at particular scores. Table 16 shows the frequencies of each reversal that occurs in the Elcho and Hermannsburg groups, and the scores at which these reversals occur.

In both groups the most frequent reversal occurring is that between weight and length at score 1. Apart from this there is no other reversal which is found occurring consistently in both groups. Except where the test on number is involved, the same reversal is found at the same score in the two groups.

Analysis of Deviations

The deviations for each test were analysed according to whether the obtained response was more or less advanced than the expected response. This is shown in Table 17.

In both groups the test on length shows the greatest number of deviations. In the Hermannsburg group the majority of the deviations are more advanced responses than expected, while in the Elcho group both more and less advanced responses are found.

Both groups show a large number of errors where the response on weight is less advanced than expected. This is an important finding, and will be referred to later in relation to the effects of experience and the invariant order of conservation of quantity, weight and volume postulated by Piaget and Inhelder.

Summary

When two categories of scoring are used, a substantial frequency of non-scale responses showing a L/W reversal were found in both the Elcho and the Hermannsburg groups. No other reversals were found which occurred as frequently as the L/W reversal in either group, or which were frequently found in both groups. This suggests that the complete series of tests does not constitute a true uni-dimensional scale, even though the co-efficients of reproducibility reach the .90 level. If the test on length is excluded, the series of tests would meet Guttman's criteria for a uni-dimensional scale.

TABLE 17

NUMBER OF MORE ADVANCED AND LESS ADVANCED RESPONSES THAN EXPECTED FOR EACH TEST - TWO CATEGORIES OF SCORING

Groups	Tests						
Elcho	Q	W	V	L	A	N	Total
Responses more advanced	-	-	7	5	6	2	20
Responses less advanced	2	9	3	6	-	2	22
Total No. of Deviations	2	9	10	11	6	4	42
Hermannsburg	Q	W	V	L	A	N	Total
Responses more advanced	4	-	5	10	2	3	24
Responses less advanced	1	13	-	5	1	2	22
Total No. of Deviations	5	13	5	15	3	5	46

2. Three Categories of Scoring

The expected order of appearance of transitional and conservation responses is indicated in Table 18.

This is approximately the same in the Elcho and the Hermannsburg groups. The only differences, excluding those involving the test on number, are the following:

1. Q_1 is found at Score 1 in the Elcho group, but not until Score 4 in the Hermannsburg group.
2. There is a reversal of the order of A_1 and Q_2 in the Hermannsburg group.
3. There is a reversal of the order of V_2 and A_2 in the Hermannsburg group.

TABLE 18

EXPECTED ORDER OF APPEARANCE OF TRANSITIONAL AND CONSERVATION RESPONSES FOR THREE CATEGORIES OF SCORING

Score	Elcho	Hermannsburg
1	Q_1	W_1
2	W_1	L_1
3	N_1	W_2
4	L_1	Q_1
5	W_2	L_2
6	N_2	V_1
7	L_2	Q_2
8	V_1	N_1
9	A_1	A_1
10	Q_2	N_2
11	V_2	A_2
12	A_2	V_2

1 = Transitional

2 = Conservation

Scale and Non-Scale Types

The total number of scale and non-scale types occurring in the two groups is shown in Table 19.

In both groups rather more non-scale types than scale types are found, but the majority of non-scale types show only one off the perfect scale. Among the scale types over half are accounted for by Scores 0 and 12.

TABLE 19

NUMBER OF CHILDREN SHOWING SCALE AND NON-SCALE TYPES - THREE CATEGORIES OF SCORING

Groups	No.	Scale Types			Non-Scale Types				
		Scores 0 & 12	Scores 1 - 11	Total	No. of Deviations				Total
					2	3	4	5-12	
Elcho	65	15	12	27	31	5	2	-	38
Hermannsburg	80	18	10	28	41	7	4	-	52

Analysis of Deviations

A further analysis of the non-scale types was made to determine what type of deviations were occurring.

The deviations were first of all categorised into 2/1, 0/1, and 0/2 deviations (2 - Conservation, 1 - Transitional, 0 - Non-conservation). The results of this analysis are shown in Table 20.

TABLE 20

PERCENTAGE OF 2/1, 1/0 and 2/0 DEVIATIONS

Groups	Deviations		
	2/1	1/0	2/0
Elcho	36	57	7
Hermannsburg	36	55	9

The percentage of each type of deviation occurring is closely similar in the two groups, 1/0 errors being the most common type of deviation found, followed by 2/1 deviations. Only a small percentage of 0/2 deviations are found.

These findings clearly support the intermediate position of the transitional stage of development. They also suggest that the Non-conservation/Conservation responses may follow a near perfect scale, while the transitional responses show greater divergences from the scale.

An examination of the non-scale types did not reveal a substantial frequency of any particular type.

An analysis of deviations was made to determine if there was any tendency for these to occur in association with particular tests.

First, where deviations involving only two tests occurred, the number of reversals for each pair of tests was determined. The most frequent reversals found are shown in Table 21.

A tendency was observed for reversals of volume and area to be most frequently found in the Elcho group, and for reversals of weight and length to be most frequently found in the Hermannsburg group. Reversals of quantity and length also tended to occur in both groups. No other clear tendencies were observed.

A further analysis was made of the deviations occurring for each test, these being classified into

TABLE 21

MOST FREQUENT REVERSALS WHEN DEVIATIONS FOUND IN TWO TESTS ONLY

Reversals	Elcho	Hermannsburg	Total
W/L	3	8	11
Q/L	4	5	9
V/A	6	2	8
Q/W	2	5	7
V/L	-	4	4
A/N	-	4	4
V/N	-	3	3
L/N	1	2	3

responses which were more advanced and less advanced than expected. This is shown in Table 22. The number of each category of deviation for each test is shown in Table 23.

In both groups deviations were found most frequently on the tests on length and quantity. In the Hermannsburg group deviations were also frequently found in the test on weight. The tests on area and volume also tended to show a high number of deviations in both groups.

In the test on length, the deviations were both more advanced and less advanced than expected. This is probably accounted for by the relative difference in difficulty of this test for the older and younger children, the older children tending to give a less advanced response than expected, the young children tending to give a more advanced response than expected.

TABLE 22

NUMBER OF MORE ADVANCED AND LESS ADVANCED RESPONSES THAN EXPECTED FOR EACH TEST - THREE CATEGORIES OF SCORING

Groups	Tests						
Elcho	Q	W	V	L	A	N	Total
Responses more advanced	3	3	11	10	11	4	42
Responses less advanced	15	5	4	8	4	4	40
Total No. of Deviations	18	8	15	18	15	8	82
Hermannsburg	Q	W	V	L	A	N	Total
Responses more advanced	13	1	12	16	11	11	64
Responses less advanced	8	22	3	13	5	4	55
Total No. of Deviations	21	23	15	29	16	15	119

In the test on quantity, the Elcho group tended to give less advanced responses than expected, while the Hermannsburg group tended to give more advanced responses than expected. In both groups most of the errors for quantity were 0/1 errors. This suggests that the difference between the Elcho and the Hermannsburg groups on quantity is due to the difference in the expected order of appearance of transitional quantity in the two groups.

The deviations for weight were generally less advanced than expected, particularly in the Hermannsburg group where a greater number of errors for weight was found.

TABLE 23

CATEGORIES OF DEVIATIONS ON EACH TEST

Groups	Category of Deviation	Tests					
		Q	W	V	L	A	N
Elcho	0/1	15	5	5	5	9	9
	2/1	3	3	9	7	6	3
	0/2	-	-	1	5	-	-
		Q	W	V	L	A	N
Hermannsburg	0/1	16	10	10	9	12	8
	2/1	5	9	5	17	2	5
	0/2	-	4	-	3	2	2

0/1 and 2/1 errors were found for all tests. The 0/2 errors were found mainly on the test on length in both groups, the Hermannsburg group also showing 0/2 errors on weight, area, and number.

Obtained and Expected Frequencies of each Score

The obtained and expected frequencies for each score are shown in Table 24. From this table it can be seen that there tend to be large differences between the obtained and expected frequencies, particularly at the lower scores. These differences account for quite a large number of the obtained deviations. For example, in the Elcho group transitional reactions are found on quantity, weight and number in almost the same number of cases, and it would be expected that these would all appear at approximately the same time. However, there are a large number of children showing transitional responses in only one or two cases. This means that deviations occurring at Scores 1 and 2 could contribute quite markedly to the total error, whereas in fact such errors are probably relatively unimportant.

TABLE 24

EXPECTED FREQUENCIES AND OBTAINED FREQUENCIES AT EACH SCORE

Score	Elcho Group N=65			Hermannsburg Group N=80		
	Frequencies			Frequencies		
	Expected	Obtained	Diff.	Expected	Obtained	Diff.
0	25	10	15	26	12	14
1	1	9	8	2	6	4
2	0	8	8	8	7	1
3	5	7	2	1	14	13
4	8	4	4	6	8	2
5	1	2	1	7	7	0
6	1	1	0	5	4	1
7	1	3	2	1	2	1
8	3	2	1	2	2	0
9	2	4	2	7	6	1
10	1	4	3	0	3	3
11	6	6	0	4	3	1
12	11	5	6	11	6	5

Summary

Where three categories of scoring were used no substantial frequency of a non-scale type was found. Since the co-efficients of reproducibility were less than .85 in both groups, the data may be said to indicate a quasi-scale for this particular set of items. That is to say, the total score of the individual is determined by one major factor, and the errors that occur are random or due to a number of minor variables, as in the case of a true scale.

It is suggested that the following variables may be contributing to the obtained errors.

1. The effects of experience, which operate in some individuals but not others, according to the stage of development reached.

2. The instability of the transitional stage of development, such that the responses of children at this level are not necessarily true to scale, since they are more easily influenced by experience (related to [1] above).

3. The difficulty of distinguishing between non-conservation and transitional responses in some cases, leading to some errors of classification (see discussion of classification of responses, p.198-201).

These points will be considered in more detail in the discussion of the results.

Reliability of the Tests

White and Saltz (1957) point out that the techniques of computing reliability co-efficients from a single test administration employ exactly the same data which are used to compute reproducibility or homogeneity. They point out that a test which shows perfect reproducibility will also show perfect reliability. The critical difference between 'reproducibility' and 'reliability' is in the interpretation of the indices; a low reproducibility figure is interpreted as an indication of item heterogeneity, while a low reliability figure is interpreted as an indication of considerable error variance.

Loevinger (1948) states that her concept of homogeneity was developed as an alternative to the concept of reliability.

The high co-efficients of reproducibility and homogeneity obtained may therefore be taken to indicate also high reliability of the tests.

The close correspondence between the results of the Elcho group and the Hermannsburg group may also be taken as an indication of the reliability of the tests.

CHAPTER VII

QUALITATIVE RESULTS - DESCRIPTION AND DISCUSSION

Detailed analyses were made of the children's responses on all the tests. The aim of these analyses was to determine whether any consistent patterns of response or types of error were occurring, and to compare the processes of development found in Aboriginal children with those described by Piaget.

These detailed analyses of the children's responses took up a major portion of the time devoted to the analysis of the results, and were considered an essential preliminary to the statistical analyses, and an important check of the stage classifications. However, only those results which are of particular interest or which are relevant to Piaget's theory will be reported here. Tables showing the results of some of the main analyses carried out are given in Appendix 5.

These results will be discussed under the following headings:

1. The consistency of the children's responses.

   This will cover certain general points which are applicable to all the tests.

2. The tests on quantity, weight and volume.

   The main findings on these tests will be reported under the following sub-headings:

   1. Explanations.

      A. Non-conservation explanations

      B. Conservation explanations.

2. Supplementary Questioning
    A. Quantity
    B. Weight
    C. Volume

3. Length.

4. Area.

Since the findings on length and area are quite distinct from those on quantity, weight and volume, and since they raise certain points of particular interest, they will be discussed separately. The test on number will not be discussed here; the main findings on this test are similar to those reported for quantity, weight and volume.

5. Evaluation.

1. <u>Consistency of Children's Responses</u>

It was found that inconsistencies between conservation and non-conservation judgements occurred at all stages of development. Any attempt to classify the children solely on the basis of the number of their conservation judgements was found to be quite clearly inadequate.

Our analysis of the children's responses led us to conclude that inconsistencies can be caused by different factors at different levels of development.

At the non-conservation level a number of children made conservation judgements which were clearly not genuine. There were two main characteristics by which these could be distinguished from genuine conservation responses:

1. They were always immediately corrected by a rephrasing of the question. For example, a child who answered 'yes' to the question 'Is the sugar in the two glasses the same?', and who was then asked 'Does one glass have more sugar?' would immediately answer 'yes' and point to the glass which he thought contained more. In this case the immediate and unhesitant indication of which glass had more sugar indicated that this was the child's genuine belief.

2. When asked for an explanation of his conservation judgement, the child was usually unable to give any explanation at all, or gave a contradictory explanation. That is, he would say that it was the same 'Because it's lots' or 'Because it's a big glass'.

In general, these non-genuine conservation responses seemed to arise from random answers, inattention, fatigue, irritation, confusion, or misunderstanding.

The genuine conservation responses of the transitional stage of development could be distinguished from these non-genuine responses by the following main criteria:

1. The conservation responses tended to be more persistent, and the children were usually able to resist suggestions of non-conservation on at least one occasion.

2. An explanation was usually given for the conservation judgement. This was in most cases a repetitive explanation ('it's the same because it's the same') but some children succeeded in giving at least one correct

explanation. Fewer contradictory or irrelevant explanations were found for these responses.

While in most cases the distinction between genuine and non-genuine conservation responses could be made on the basis of these criteria, there were a few cases in which the distinction was not very clear, or in which both types of response appeared to be occurring.

At the conservation level a few inconsistencies were also found. These were usually found only initially, but in some cases occurred after questioning.

Where these occurred initially, they appeared to be due to an initial non-conservation which was completely and immediately rejected as soon as the child's attention was drawn to the problem and to the contradictions of non-conservation.

Those occurring during questioning seemed to be due to the following factors:

a) A still uncertain conservation, indicating that conservation had only just been achieved, or was still in the process of being achieved.

b) A misunderstanding or confusion of the question.

c) A lack of confidence in their own judgement, which led the children to give what they thought was the required answer, rather than what they actually believed.

The inconsistencies of the conservation level were distinguished from those of the transitional level in that they were only occasional and the final conservation shown was quite firm and stable.

The analysis of inconsistencies in the case of quantity and weight is shown in Appendix 5, Tables 1 and 2. The children's preferences for which quantity is judged to be more, to be heavier, and to have greater volume is shown in Tables 3, 4 and 5.

2. Quantity, Weight and Volume

1. Explanations

A. Non-conservation Explanations.

Two main types of explanation were found for non-conservation judgements:

Type A.

i) The explanations 'It's lots', or 'It's more'.

ii) The explanation 'Full'.

In the case of quantity and weight, these explanations referred to the sugar or the tea leaf. In the case of volume, these explanations referred to the water in the glass.

Type B.

i) Explanations referring to size; 'It's big', 'It's bigger' or 'It's big and little'.

ii) Explanations referring to shape; 'It's round', 'It's long', 'It's lots of little glasses', etc.

In the case of quantity and weight, these explanations referred to the containers. In the case of volume, these explanations referred to the plasticine itself.

The majority of explanations that were given could be classified into these two main types (see Appendix 5 Tables 6, 7 and 8).

The explanations which could not be classified into these groups were as follows:

1. The explanation 'heavy' was given by several children in the case of weight and volume.

2. Contradictory explanations; that is, explanations which did not agree with the child's judgement. For example, the explanation 'same' would be given to the judgement that one glass had more sugar.

3. Irrelevant explanations, e.g., 'He's hungry', I think so', 'I don't know'.

These explanations appeared to arise either from a failure to understand the problem, or from a failure to understand what sort of an explanation was required. In some cases, the children seemed to think that the answer was so obvious that it did not require an explanation. One eight year old child consistently gave the explanation 'Because I play with the rods' (referring to Cuissenaire) for her judgements on <u>all</u> the tests, including weight, volume, length and area. It was not clear whether this was simply a random response, or whether the child saw some connection between the test situations and her experiences with the Cuissenaire materials. This subject was one of the brighter eight year olds.

4. The explanation 'different'.

While this explanation was given by only a few children, it was particularly striking because it seemed to express very clearly the difficulty which some of the children experienced on these problems; that is, the reasoning 'It's different, and therefore it can't be the same'. It also seemed to suggest that to the child because the quantities were 'different' (in form) they could not be compared as to their relative amounts.

This problem may be related to their linguistic background. In the translation of the test on length, it was noted that the word to translate 'same' also meant 'together' in the sense that the sticks were placed parallel and with their ends coinciding. The word 'same' might therefore imply to these children not only same amount or quantity, but also the same shape and form.

5. Other explanations

In the case of quantity, the explanation 'half' was used in the sense of 'divided up' with reference to the four small glasses, or to refer to the lower level of the sugar in one glass than in another glass. The imprecise use of this term may be noted. The explanation 'more room' was also given in one case. This explanation is of interest in that it refers to an abstract concept of space or volume. It was given by a 13 year old transitional subject.

In the case of weight, one 14 year old subject gave the explanation 'because it's tight'. This is of particular interest since it shows the confusion between weight and density noted by Piaget. While this explanation was found in only one case, it was given by a boy who expressed himself much more easily and freely than most of the other children. This suggests that the absence of this explanation may have been due to the children's difficulty in expressing themselves rather than to the absence of this confusion.

In general, it was found that most of the explanations for non-conservation judgements referred to the immediate perceptual situation. This supports Piaget's view that non-conservation is due to the child's inability to free himself from his immediate perception through lack of an operational system with which he can link his present perceptions to past or to future situations.

B. Conservation Explanations

Four main types of explanation were distinguished for conservation judgements:

1. Correct explanations.
2. Repetitive explanations.
3. Irrelevant explanations.
4. Contradictory explanations.

The number of children giving each of these types of explanation is shown in Appendix 5, Tables 9, 10 and 11.

The majority of the correct explanations referred to what Piaget terms 'identity', that is, the fact that the quantity was the same before. In some cases the reference to the previous state was explicit (e.g., 'It was the same before', or 'I saw it before'), in other cases it was implied (e.g., in the test on volume, some children said 'Same ball' or 'Same round', clearly referring to the original form of the plasticine). In the test on weight, a number of the correct explanations referred to the balance (e.g., 'I saw it here' [on the balance] or 'It was the same on the balance').

Only a few correct explanations were given referring to the transformation of the quantity, corresponding to Piaget's explanations based on reversibility. In the test on quantity only seven children gave such explanations. Four of these referred to the fact that the sugar had been poured from one glass to another, while three referred to the fact that if the sugar was put back into the original glass, it would be the same.

In the test on weight, only one explanation was given referring to the transfer of the tea leaf from one bag to another. Two explanations referring to transformation were given in the case of volume; ('When you roll this ball into a round one it will look the same', and 'Because it was still the same size when you push it flat').

No correct explanations referring to compensation were found. However, in some cases the explanations classified as contradictory did appear to be attempting to express compensation. For example, in the test on quantity, one child consistently gave the explanation 'That one's got round' for consistent conservation judgements. In this case the child may have meant that the sugar <u>looked</u> different because one glass was round (the wide glass), but that the sugar was really the same. Some explanations which simply gave descriptions of the situation also seemed to imply compensation. For example, in the test on volume, a number of children said 'Because this ball is round and this one is long' when asked to explain their conservation judgement. This seemed to imply that although the plasticine is a different shape, it is the same amount or volume, and that the length compensates the roundness and vice versa. This explanation was found at both the conservation and non-conservation levels and may imply compensation in some cases.

The correct explanations given by the children therefore correspond to those described by Piaget, but are based mainly on identity. This is in agreement with Lovell and Ogilvie's (1960) findings on English children, although they classify the explanation 'It was the same before' as referring to reversibility and not to identity. In our view the explanations referring explicitly to transformations correspond more closely to what Piaget refers to as explanations based on reversibility.

It is possible that the failure of the children to give explanations referring to compensation, and the few explanations referring to transformation, may be due to the children's more limited ability to express themselves clearly. It was noted that the explanations referring to transformations were usually given by those children who were able to express themselves more fluently.

The repetitive explanations would also appear to be based on identity, but appear to be less advanced than those referring explicitly to the previous situation, and may accompany non-genuine conservation responses. In most cases the children were encouraged to clarify these explanations by being asked 'How do you know that it is the same?', and in a final effort to get more clarification they were asked 'Where did you see that it was the same?'. This last question often succeeded in distinguishing between those children who clearly understood the problem, and pointed immediately to the standard glass or the standard bag (some even going carefully through the pile of plastic bags on the table to find the right bag), while other children simply pointed to the glasses or bags in the present situation.

In the test on volume, two children also gave the explanation 'same heavy' to explain conservation of volume. This is consistent with Piaget's view that once conservation is achieved for quantity, weight and volume, these qualities are seen to be interdependent, and any one can be justified with reference to any of the others. It may also be related to the tendency to explain the rise of water in the glasses in terms of a force exerted by the object on the water.

A few irrelevant explanations were given, and these seemed to be due to random answers or a misunderstanding of the problem, or to the fact that the child did not understand what sort of explanation was required, or the answer seemed to him to be so obvious that it did not require an explanation.

Contradictory explanations seemed to arise from two main causes:

1. Random or non-genuine responses.
2. Uncertainty and changes of judgement.

The explanations given for conservation judgements therefore tend to support Piaget's view that conservation is achieved when the child is able to link his present perception with past or with future perceptions and so to recognise 'identity'.

2. Supplementary Questioning

A. Quantity

i) Answers to the question 'If the sugar was put back into here (A') would it be the same as in here (A)?'.

Most of the children were able to state correctly that if the sugar was put back into A', it would be the same as in A (see Appendix 5, Table 12A). These answers would correspond to what Piaget terms 'an empirical return the starting point', which does not imply a logically necessary conservation since the end states are not linked by a reversible system of transformations.

A number of children judged that the sugar would not be the same when put back into A'. These answers appeared to fall into two distinct groups:
a) Those that were due to a misunderstanding of the question, the children making a judgement about the present situation rather than the hypothesised situation.

b) Those where the child actually believed that the glass which they judged to have more sugar would still have more sugar when it was returned to A'. This was, in a sense, the conservation of a non-conservation judgement.

These two types of response could usually be distinguished by asking the child to point to the glass which he thought would have more sugar.

An analysis of the judgements made immediately following the 'put back' question indicated a tendency to give conservation judgements following this question (see Appendix 5, Table 12B). At the non-conservation level these appeared to be due mainly to a misunderstanding of the question, and did not lead to any clear understanding of conservation. At the transitional level this question did not seem to have a very marked influence on the children's understanding of conservation; many children who had previously given conservation responses did not give a conservation response immediately following this question, and of those who did many had previously given some conservation responses.

These observations indicate that the suggestion of putting the sugar back into the original glass does not have a marked effect on the child's belief in non-conservation or on his understanding of conservation. However, a systematic study of this problem would be required before any conclusion can be drawn.

ii) Answers to the question: 'Is the sugar the same to eat?'.

In the Hermannsburg group a tendency was noted for the children to judge that the quantities of sugar would be the same for the dolls to eat, even though they had just judged that one quantity was more (see Appendix 5, Table 13). In some cases this judgement seemed to arise from a clear misunderstanding of the question, the children apparently meaning that the dolls would have the same substance, sugar, to eat, and not that they would both have the same amount of sugar to eat. This was made clear by their explanations (e.g., 'Same white sugar'), for their 'same' judgement, and by their insistence that one glass had more sugar on later questions.

However, it was noted that the tendency to judge that the sugar was the same 'to eat' after an initial non-conservation judgement was found more often and more consistently in the transitional group of children, suggesting that the children may grasp conservation more readily when the notion of quantity is related to the amount each doll actually has to eat.

Again, a systematic study of this problem would be required to determine whether this form of the question does influence the child's judgement.

B. Weight

i) Consistency between weight and balance judgements.

It was noted that some children tended to show clear and persistent inconsistencies between their judgements as to which bag was heavier, and which would make the scale go down. A closer analysis of these inconsistencies was therefore made (see Appendix 5, Table 14A, B and C).

The tendencies indicated in these tables suggest that in the Hermannsburg group conservation is more easily recognised when the question is referred to the balance, and that conservation is achieved when the child rejects non-conservation judgements of weight which conflict with conservation judgements related to the balance.

This tendency was not found in the Elcho group.

Possibly relevant to the difference between the groups is the fact that some of the Hermannsburg children (those in Grade 3, including mainly the 9 and 10 year old age groups) had been given some teaching relating to the use of the scale, while the Elcho children had not. Conversation with the teacher concerned indicated that this teaching had emphasised the use of the scale to 'measure' quantities, and that no reference had been made to weight, or to the principle on which the scale worked.

ii) Additional questioning on Part 4 when A was compared with 1, 2, 3, 4 or 5 of the 6 small bags.

In some cases the child was asked to compare the standard bag A with only 1, 2, 3, 4 or 5 of the 6 small bags. This questioning was introduced to check doubtful cases, and was asked mainly in the Elcho group.

Of the children questioned all those at the conservation level answered correctly, although in some cases after some initial doubt, while none of the children at the non-conservation or transitional levels were able to do so.

The incorrect responses could be divided into a series of stages according to the degree of error they showed.

Extreme errors were shown by children who judged that less than the complete number of small bags was either equal to A or was heavier than A. Some children judged that one small bag was equal in weight to A, and other children judged that only two small bags would be heavier than A. These responses clearly distinguished non-conservation cases from transitional and conservation cases.

Some children consistently judged A to be heavier when it was compared with fewer than the 6 bags, but when all the small bags were present judged either A or B's to be heavier. These responses were more advanced than those of the previous level, but still at the non-conservation level of development.

Some of the children tended to judge that the quantities would weigh the same if only one bag was missing. Of these children, some tended to judge that they would weigh the same when all the bags were present, and some tended to judge that the small bags would be heavier. These responses seem to indicate an approach to a transitional level of development, where the child begins to understand that weight depends on the amount of tea leaf present, but still seems to think that a little tea leaf more or less will not make any difference.

Finally some children consistently judged that A would be heavier when fewer than 6 bags were present, but when all the small bags were present showed indecision between conservation and non-conservation judgements. These responses indicated a transitional level of development.

iii) Additional questioning on Part 4 when A and B's were actually placed on the scale.

Because there was slightly more plastic in the 6 bags than in bag A, these bags were actually slightly heavier than A, and when placed on the scale tended to make the scale go down slightly, clearly showing a difference in weight. In the Hermannsburg group it was decided to place the bags on the scale at the conclusion of the questioning to test the children's reaction to this demonstration. This was done only in a few cases of clear conservation.

The responses to this demonstration fell into two groups.

Some children realized that the tea leaf must be the same weight as it was before, and therefore concluded immediately that it must be the plastic that was heavier in the 6 small bags and was therefore making the scale go down.

Some children reverted to non-conservation in the face of this evidence, and judged that the tea leaf must be heavier. They maintained this judgement even when they were asked if it could be the plastic bags that were heavier in the small bags, and when they were reminded by questioning that the tea leaf had weighed the same initially.

Of the seven children questioned in this way, four showed the first type of response, and three showed the second type. One of the latter three had shown some initial inconsistencies of judgement, but in the other cases there was nothing to distinguish the original conservation responses of the children.

C. Volume

i) Introduction

On the whole the children found little difficulty in understanding the principle of displacement in water, and understood that the larger the object immersed the higher the water would rise. A number of children tended to judge that the small ball would not make the water rise. When questioned further, most of these children admitted that the water would rise a little. In a few cases the demonstration had to be repeated before the children finally admitted this.

When asked for explanations as to why the balls made the water rise, most of the children referred to the fact that the balls had been put inside the glasses, that the water came up or was full, or that the balls were little or big.

When asked for explanations as to why the big ball made the water rise higher than the small ball, virtually all the children referred to the sizes of the balls; 'It's big', 'It's little', or 'It's big and little'. Some children also referred to the water, e.g., 'It's full'. A few children in both groups used the explanation 'heavy', and one child in the Elcho group used the explanation 'strong'. This explanation supports Piaget's view that initially displacement of water is regarded in terms of some kind of force which is exerted on the water by the object, rather than in terms of the volume or the space occupied by the object.

The majority of children judged immediately that when two equal-sized balls were put into the water, the water would rise to the same level in the two glasses. The explanations given were usually 'Same', 'Same ball', 'Same round one', or 'Same size'.

A few children showed inconsistencies in these judgements, which seemed to be associated with random responses and a failure to understand the problem, indicating a primitive level of development.

ii) Consistency between judgements and drawing.

An analysis was made of the consistency between the children's judgements of volume and their drawings of the water level in the sketches. The results of these analyses are shown in Appendix 5, Table 16.

These indicate that in the majority of cases in both groups a consistency between drawings and judgements was found. In the Hermannsburg group it was noted that in the majority of cases where the drawing conflicted with the judgement, or where the judgements were inconsistent, the levels were drawn unequal following conservation judgements. This tendency was not found in the Elcho group.

Observation of the children's reactions on this problem suggested that in most cases it was the drawing that reflected the child's genuine belief. Many children who made inconsistent judgements immediately drew the level of water higher in one glass, and were quite firm in their statement that the water would come higher. The higher level was almost invariably shown for the ball, even in those cases where the child had previously judged the other quantity to have a greater volume (as seen in Table 5, Appendix 5, there was a clear preference for the ball to be judged to have greater volume). In some cases, the inconsistency between drawing and judgement appeared to indicate a transitional level of development, where the child was still uncertain as to conservation.

The drawings were generally found to be an extremely valuable check on the children's judgements.

iii) Questioning on Quantity

The supplementary questioning included questions on the quantity of plasticine in each case, and an analysis was made of the number of children showing conservation of quantity.

At the transitional level the majority of children showed conservation of quantity in all or most cases. At the non-conservation level some children showed conservation of quantity in some cases, but few children showed consistent or reliable conservation of quantity. Some children at this level who showed non-genuine conservation responses for volume showed clear non-conservation of quantity.

An examination of the responses indicated some tendency for children to give judgements of conservation of volume following the questioning on quantity, particularly in the transitional group. This suggests that questioning on quantity may help the children to achieve conservation of volume. However, this question would require systematic examination before any conclusion could be drawn.

In some cases a fairly clear tendency was observed for the children to judge that one quantity had more plasticine (usually the transformed plasticine), while the other had greater volume (usually the ball). No reason for this can be suggested.

3. Length

For the test on length an analysis was made of the children's conservation judgements when the questioning related to length, distance, and time (see Appendix 5, Table 17).

No clear tendency was found for conservation to be related to the form of the questioning.

There was a clear tendency in both groups for the children to judge that the stick which had been moved was longer (see Appendix 5, Table 18). This is in agreement with Piaget's findings (see p.93). A tendency was also observed for judgements that the stationary stick was longer to increase with the questions relating to distance and time, as compared with those relating to length only. A tendency was also noted for the children to judge that the same stick was both longer (length) and quicker to walk (time).

Explanations

1. Non-conservation Explanations

The non-conservation explanations given by the children could be divided into the following types:

A. Explanations referring to the size of the sticks, e.g., long, short, big, small.

B. Explanations referring to the position of the sticks, e.g., up, down, top, higher, further, first, last.

C. Explanations referring to the movement of the sticks, e.g., you pushed it, you moved it, you put it up.

D. Irrelevant explanations, e.g., straight, quickly, run, walk.

E. Contradictory explanations, i.e., same.

F. The explanation 'different'.

The number of children giving each of these types of explanation is shown in Appendix 5, Table 19. In both groups Type A explanations were most frequent at all stages of development.

In both groups there was a clear and consistent tendency to give seemingly contradictory explanations for judgements on time or quickness. The children would judge that one stick was quicker to walk because it was longer or bigger, or that it took 'longer time' to walk because it was shorter or smaller. This type of contradictory explanation was clearly related to the tendency noted previously for the children to judge the same stick to be both longer and quicker to walk, or to be both shorter and to take 'longer time' to walk. Persistent questioning which attempted to confront the child with the inconsistency of these judgements and explanations failed to make the child change either his judgement or his explanation, and clearly indicated that these responses were not random or accidental, but reflected the genuine beliefs of the child.

This apparent inconsistency between judgements and explanations of length and speed are explicable in terms of Piaget's theory of the development of these concepts. At the non-conservation level length is said by Piaget to be judged in terms of the order of the end points, and the stick which is seen to be ahead or in front of the other is judged to be longer. At the same time Piaget has demonstrated that judgements of speed are made in terms of which object is behind the other. The ant that is imagined to be walking and arriving ahead of the other ant is therefore judged to be walking quicker and taking less time. Thus the stick that is seen to be ahead in terms of the position of its end points is judged to be longer in terms of length, but quicker in terms of speed, and that which is seen to be behind or trailing the other is judged to be shorter in length but to be slower or to take longer time to walk.

These findings give strong support to Piaget's view that at this level the child fails to take into account the total length of the stick, that is, the interval between the end points, and judges length in terms of the order of the end points only.

2. Conservation Explanations

The explanations for conservation judgements were classified into the same main groups as in the case of quantity, weight and volume. These were:

1. Correct explanations.

These explanations referred explicitly or implicitly to the fact that the sticks were the same before. Some of the children spontaneously put the sticks back to their original position to demonstrate this, others did so only when asked how they knew they were the same, or how they saw that they were the same.

2. Repetitive explanations.

These included the explanations 'same', 'same length', and 'same size' (the explanation 'same stick' was regarded as an implicit correct explanation).

3. Irrelevant explanations.

4. Contradictory explanations.

The number of children giving each of these types of explanation is indicated in Appendix 5, Table 20.

Part I

The children's responses on Part I of this test[1] were not considered in the classification of conservation of length, but were scored separately. Three stages of development were distinguished:

I. The child's judgement of length was made in terms of the end points only. Where these coincided the sticks were judged to be the same length, regardless of whether they were straight or curved.

II. Where the end points coincided, the child was able to see that the curved stick was longer, or was longer to walk, or would take more time to walk, and that the straight stick was quicker. But where the ends of the straight stick overlapped those of the curved stick, the child judged that the straight stick was longer, longer to walk, and took more time to walk, and that the curved stick was quicker to walk.

III. The child understood that the curved stick was longer, longer to walk, or took more time to walk in all situations, and the straight stick was quicker to walk.

The total number of children classified at each of these stages in each group is shown in Appendix 5, Table 21. It was noted that correct judgements were most frequent for the questions relating to time, less frequent for questions relating to distance, and few

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1 See Procedures p.184.

children gave correct judgements for the questions relating to length only (Appendix 5, Table 22).

Our test differed from that described by Piaget in that we added the situation where the curved stick was adjusted so that it was overlapped by the end points of the straight stick. Our classification of the responses also differed from Piaget's. By introducing this additional situation we were able to distinguish between those children who were able to answer correctly on the time questions only when the end points coincided, and those who were able to answer these questions correctly for all situations.

Piaget required correct answers to the questions on length as an indication of the child's dissociation between length and the position of the end points, while we have accepted the child's correct answers on the questions relating to time as indicating this dissociation. Piaget found that questions relating to length were answered correctly prior to Stage III, which marks the achievement of conservation of length and concrete operations. We found that many of our children who showed clear conservation of length failed to answer the questions on length correctly in this situation. It therefore appeared that this difficulty arose from a misunderstanding of the term 'length'.

It is not clear whether correct answers to the questions on length indicate a more advanced level of development or only a different verbal usage. This question requires further investigation before any conclusion can be drawn.

Comparison of Parts I and II

No clear relationship was found between performance on Parts I and II, and more children succeeded on Part I than on Part II (see Appendix 5, Table 23). Since Piaget found that the problem of Part I was solved before the achievement of conservation, these findings are as expected.

A few cases classified at Stage I on Part I showed transitional or conservation responses on Part II. Examination of the score sheets suggested that these could be due to:

a) Misclassification on Part II.
b) A verbal confusion in Part I of the test, resulting in a child at an advanced level failing to understand this problem.

An examination of the explanations given for the children's judgements indicated that the explanations 'straight' and 'crooked', or an equivalent phrase or gesture, was most frequently given for correct judgements. The explanations 'long' and 'short' or 'big' and 'little' were given for both correct and incorrect judgements, and in a few cases contradictory explanations were given.

A fairly persistent explanation found for the judgement that the straight stick was quicker was the explanation 'long'. This appeared at first sight to be a contradictory explanation, but it was consistently given by some children who gave clear and firm judgements and showed no other indication of random or contradictory responses. For this reason it was thought that this may be due to a terminological confusion between 'long' and 'straight'. However, information received from Mr T.G.H. Strehlow suggests no basis for this confusion in their own language, since these terms are quite distinct.

4. Area

The responses on the test on area were not analysed according to the consistency of conservation and non-conservation judgements, as in the case of the other tests, since in this test it was the point at which conservation broke down that was important. The non-conservation responses were therefore divided into a series of levels according to the pattern of conservation and non-conservation judgements.

These levels were as follows:

A. Complete or partial failure to understand the problem.

At this level the children failed to understand that the amount of grass available for the cow to eat was related to the number of houses on the field, even when there were a large number of houses on one field and no houses on the other. Answers were in all cases inconsistent and appeared to be random. In some cases the children did appear to show some slight understanding after careful and repeated explanation of the problem, but they reverted almost immediately to inconsistent and random answers. This level would probably correspond to Piaget's Stage I, where he reported that he was unable to carry out testing. He found this level up to about $4\frac{1}{2}$ years in Swiss children.

B. Non-conservation responses occurring when only 2, 3 or 4 houses were placed on the field.

At this level initial doubts of conservation occurred in many children when only two houses were placed on the fields. Often conservation responses would be given after questioning, but at the next pair of houses immediate non-conservation responses would again be given. In some cases the period of inconsistent answers continued up to 4 or 5 houses, but consistent non-conservation responses were generally given from about 4 to 6 houses.

C. Non-conservation responses occurred initially when about 5 to 7 houses were placed on the fields, and consistently when about 9 or 10 houses were placed on the fields.

In this group the initial non-conservation responses were given rather later than in the previous group, and the period of inconsistency generally lasted longer before consistent non-conservation judgements were given.

D. Non-conservation responses occurring only after the number of houses on each field was varied.

A number of children gave conservation responses up to about 12 houses, but immediately the number of houses on each field was varied by placing two houses on one field and none on the other, the child started giving consistent non-conservation or incorrect responses.

The number of variations introduced in the questioning and procedure of this test (see Procedure p.189) made a standard analysis and comparison of the responses difficult. However, the more important tendencies noted at each level are reported.

At level B it was noted in a number of cases that the children continued to judge that field A (houses in a line) had more grass when houses were added to A only. In one case the child continued to judge that field A had more grass even when up to 20 houses were added to A and only 3 houses were on B. In another case A was judged to have more grass up to A_9 B_3 (i.e., 9 houses on A, 3 on B), when B was judged to have more. One house was then added to B, and A was again judged to have more grass up to A_{22} B_4. B was then judged to have more up to A_{22} B_9, when A was again judged to have more.

The procedure of continuing to add houses to the field judged to have more grass was not adopted in all cases, and was not always continued up to a change in judgement. Nevertheless, the tendency to continue judging A to have more grass when it had many more houses than B was found to be quite widespread, and, as the illustrations quoted indicate, could be continued to great extremes. That this was not due to misunderstanding is clear from the changes in judgement that occurred.

The responses at level C showed the same general characteristics as those at the previous level, and the tendency to continue judging field A to have more grass as more houses were added also occurred. Some children who made conservation judgements up to 10 or 12 houses then continued to judge that field A had more grass when houses were added to A only, in one case even when up to 20 houses were on A and only 10 houses were on B.

At level D two distinct types of response occurred following the variation of the number of houses. These were:

a) Those cases where A was judged to have more grass in most or all the following cases.

b) Those cases where there was a tendency to judge the fields to have the same amount of grass regardless of the number of houses.

The majority of children at level D showed the first type of response. The second type of response appeared to indicate a misunderstanding of the problem or random answers, and therefore a more primitive stage of development.

If the conservation judgements made until the variation of the test at level D were genuine, the question as to why this conservation broke down as soon as the number of houses was varied is posed.

Three possible causes may be suggested:

1. When the number of houses is the same, the inference that the remaining area of grassland is also the same is fairly straightforward; but when one field has more houses, the child has to make the indirect inference that the field with <u>more</u> houses has <u>less</u> grass. This

relationship may have been more difficult for the children to work out. This may be related to the difficulty associated with indirect judgements described by Bruner, Goodnow and Austin (1956), and to the difficulty that children have in dealing with negative statements noted by Donaldson (1962).

2. After judging conservation for the first few pairs of houses, the child may simply persevere with this type of answer without looking carefully at the fields or without thinking very much about the problem. As soon as the procedure is changed he would have to stop and think, and at this point he may look more carefully at the fields, and so become influenced by the perceptual appearance of a greater expanse of green, thus judging this field to have more grass.

3. What is involved may be simply the focus of attention. When one house is added to each field simultaneously the child's attention is focussed on the equality of the houses, and he infers conservation. As soon as the number of houses is no longer equal, he switches his attention to the perceptual appearance of the fields. Once his attention is drawn to the perceptual appearance he is no longer able to think about the equality of the houses, even when he is reminded of this equality, because he is now dominated by the perceptual appearance.

These suggestions are only tentative, and further investigation of the types of response that occur at this level is required.

Transitional Responses

The responses classified as transitional showed a clear conflict between judgements based on the perceptual appearance of the fields, and judgements based on the number of houses. Correct judgements were usually found up to about 15 houses, but as the number of houses was further increased conservation broke down. In some cases conservation judgements were found up to about 20 houses before the child relapsed into non-conservation and incorrect judgements.

In some cases it appeared that the child had lost count of the number of houses in the two fields. The child was therefore always asked which field had more houses, and his judgement of the grass was assessed according to his judgement of the houses. If he judged the number of houses incorrectly, he was asked to check them by counting.

Conservation

At the conservation level the children showed a clear understanding of the principle that the field with fewer houses would have more green grass, regardless of the distribution or the number of houses. Some of the children at this level counted the houses spontaneously when they became uncertain of the number on each field. Others seemed to keep a very careful check of the houses as they were added to the fields, and in each case they knew immediately which field had more. Where the children obviously became confused as to the number of houses, but did not spontaneously count them, they were told that they could do so.

Explanations

The explanation for conservation and non-conservation judgements of area were categorised into four main types:

1. Repetitive or irrelevant, e.g., 'It's more', 'It's lots of grass', 'Same grass', 'I think so', 'I can see'.
2. Explanations referring to the distribution of the houses, e.g., 'They're in a line', 'They're all together', 'They're put everywhere'.
3. Incorrect explanations referring to the number of houses, e.g., 'It's more grass because it has lots of houses'.
4. Correct explanations referring to the number of houses, e.g., 'It's less grass because there are more houses', or 'It's the same grass because the houses are the same'.

The number of children giving each type of explanation is shown in Appendix 5, Table 25.

Repetitive and irrelevant explanations were most commonly found at the non-conservation level, while explanations referring to the distribution of the houses were also commonly found. The children usually referred to the fact that the houses were all together or in a line in field A, few children referring to the scattered houses in B. These explanations were also found at the transitional and conservation levels.

Correct explanations referring to the number of houses were found at all levels, but at the non-conservation level these explanations were given when only a few houses were on the fields, while at the transitional and conservation levels correct explanations were found for up to 20 or more houses (see Appendix 5, Table 26).

The Later Development of Conservation of Area

Piaget found conservation of area in this situation at Stage III A, at about seven years, when conservation of quantity, length, and number are also achieved. However, in his discussion he points out that conservation of the complementary area in this situation requires an understanding of co-ordinate systems of reference, which is not achieved until a later stage. He therefore carried out a further test where the partial areas were not units, as in the case of the houses, but a square, whose parts could be rearranged to form a long rectangle. In this situation he found conservation of the enclosed area at seven years, but conservation of the complementary area was not found until Stage III B, at about nine years. The reasons which Piaget gives for the discrepancy between these results are discussed in Chapter II. It was pointed out here that these reasons are not convincing, and that this discrepancy may be due simply to the fact that in the situation of the houses where the partial areas are units the child is able to make an intuitive inference that so long as the houses are the same number, the remaining areas must be equal.

For the Aboriginal children, the test on area was as difficult or more difficult than that on volume, which Piaget has found is not solved until about 12 years. Elkind (1961a) has reported that the 75 per cent level for conservation of volume is not found until about 15 years. Lovell, Healey and Rowland (1962) found that conservation of area was in fact achieved before that of length, at about six years as compared with eight years for length. Their procedure followed that of Piaget, but they do not report the order in which the tests were presented, and this may have affected the relative difficulty of these tests. We therefore find that conservation of area is relatively more difficult for Aboriginal children than for European children.

By varying the test to put unequal numbers of houses on the fields, we may have made it more difficult, and this modified form must be applied to European children before any comparison can be made as to the relative difficulty of this test for Aboriginal and European children.

However, there are two other factors which may have contributed to this difference:

1. Aboriginal children have greater difficulty in understanding concepts of number, and are less familiar with manipulating numbers. This factor may have made it more difficult for them to make the inference that if the number of houses on the two fields is the same, the remaining grassland must be equal.

2. The fact that Aborigines do not have linguistic terms to express area may have made it more difficult for them to grasp this abstract concept and so to understand and solve the problem of conservation of area.

This test on area has raised a number of problems which require further investigation, and our results have suggested certain lines of investigation which have not previously been taken up. In particular, our finding that some children will continue judging field A (houses in a line) to have more grass even when it has many more houses than B (houses scattered) requires systematic examination. The conditions under which conservation of the complementary area is found also requires examination, and the relationship between conservation of area and conservation in other situations should be investigated.

5. Evaluation

The more important implications of our results will be discussed in Chapter IX. In the present section we will comment only on the implications of these findings for the qualitative processes of development described by Piaget, and on some general problems of the presentation of these tests.

1. Implications for processes of development.

In general, the responses and explanations given by the Aboriginal children reveal the same processes of development which Piaget has described for European children. Non-conservation responses are invariably justified with reference to the perceptual features of the present situation, while conservation responses are justified with reference to past or future situations, indicating the child's ability to link these together in a system of reversible transformations. While the explanations given by the Aboriginal children were in general more limited than those of European children, the fact that a few children gave explanations illustrating precisely the same processes of thinking that Piaget has described seems to be in itself significant. These children have been brought up in quite a different cultural and linguistic background to the European child, and have had no teaching in physical science, and yet they showed exactly the same difficulties and confusions in their notions of physical concepts. For example, the confusion between weight and density described by Piaget was expressed by the child who said that one bag of tea leaf was heavier because it was 'tight', and the tendency to regard displacement of water in terms of a force that is applied to the water rather than in terms of the volume occupied by the object was expressed by the child who stated that the plasticine made the water rise 'Because it's strong'.

These findings confirm the universality of the processes and stages of development described by Piaget.

2. Implications for test presentation.

One of the main points to emerge from our testing procedures was the importance of presenting the test in such a way that the responses were clear and unambiguous. In some situations we found that genuine answers could not be clearly distinguished from non-genuine answers, and in others we found that some feature of the situation led to a confusion of terms or misunderstanding. For example, in the test on quantity where the sugar was poured into the four small glasses it was sometimes difficult to determine whether the child was taking into account the sugar in all four glasses, or whether he was simply comparing the sugar in each of the small glasses with that in the standard glass (the latter reaction would be related to non-conservation, since it expresses the difficulty that children at this stage have with additive composition [Piaget (1952) Chapter VIII]).

Our variations in procedure and supplementary questioning suggested a number of ways in which the tests could be presented in order to obtain clear and unambiguous results. These can be summarised as follows:

1. The test situation should always present a strong perceptual illusion which can only be overcome by thinking based on operational structures.

For example, in the test on quantity, the clearest results were always obtained when the sugar was poured into the long thin glass. In the other situations the responses tended to be inconsistent and ambiguous.

2. Checks should be introduced in the procedure wherever possible. For example, in the test on weight,

the comparison of the standard bag with only some of the small bags succeeded in distinguishing between those children who were simply repeating that the quantities were the same weight for all questions, and those who were giving genuine conservation responses. This procedure also made it possible to distinguish different degrees of non-conservation.

In the test on volume, the use of drawings in addition to verbal judgements served as an important check of the verbal responses.

3. In some cases it was found that the stability of conservation judgements could be checked by variations in the problem. This is illustrated by the supplementary questioning on weight, where the children were faced with the demonstration that one quantity of tea leaf was in fact heavier. The different reactions to this demonstration revealed different degrees of stability for the concept of conservation, which were not evident from the child's performance up to this point.

Similarly, in the test on area, the variation in the number of houses on the two fields produced important changes in the children's responses.

4. Those tests where a continuous process of development can be followed, such as in the case of area, should provide a useful basis for undertaking studies of the effects of different methods of presentation, or the effects of different types of training, since in these cases the child's position on a continuous scale can be determined, and his advance measured, for example, in

terms of the point at which conservation breaks down, or in terms of the number of extra houses that can be added to the row of houses in one field before he recognises that this field must have less grass than the other.

5. It would be better to devise one clear problem for each concept studied than to repeat the problem in several different situations. Repetition of the problem tends to make the children impatient and suspicious, and is unnecessary if the one problem will give unambiguous results.

The various problems which have been raised by our findings and which require further investigation have been referred to in the discussion on each test. Most of them are concerned with the effects of different forms of presentation or questioning on the child's responses. This question has been raised by other investigators, and will be referred to again in the critical discussion of Piaget's theory in Chapter IX.

CHAPTER VIII

DISCUSSION OF RESULTS

In this chapter the results of the study will be discussed under four main headings:

1. The relative difficulty of the tests and the problem of order effects.
2. Differences in development between Aboriginal and European children, and between the Elcho and Hermannsburg groups, and environmental influences.
3. The factors of intelligence and maturation in development.
4. The differences between the full-blood and the part-blood children and the question of racial differences in intelligence.

Suggestions will be put forward to account for these results. These will be largely conjectural, and are intended to point to the problems which require further investigation rather than to provide any conclusive answers. The general implications of these findings and the problems which require further investigation will be discussed in the final chapter.

1. Relative Difficulty of the Tests and the Problem of Order Effects

It is suggested that the relative difficulty of the tests is being influenced by order effects, and that the observed order of difficulty is the result of an interaction between actual difficulty and the effects of experience on the previous tests.

That experience on the tests can lead to an improvement in performance is indicated by the difference in performance between the two groups on the test on number, this test being one of the easiest tests in the group where it was administered last in the series, but one of the most difficult tests in the group where it was administered first.

While there was a tendency for improvements in performance to occur according to the order of presentation, it was noted that:

a) Area and volume tended to the most difficult tests, although they were presented at the end of the series of tests.

b) Differences were found in the effects of experience between the younger and the older children.

This suggests that it is not experience with the testing situation per se which produces the improvement, and that the effects of experience on the previous tests will vary according to:

A. The particular test involved.

B. The level of development of the child.

A. The test involved.

It is suggested that the degree to which experience on the previous tests can lead to an improvement in performance will depend on the operational structures required for the solution of the problems.

i) If the operational structures required for all the tests are the same, marked improvements in performance will occur with increasing experience on the tests.

ii) If the operational structures required for the later tests are slightly more advanced than those required for the earlier tests, improvements in performance may be found with increasing experience.

iii) If the operational structures required for the later tests depend on a different set of operational structures, little or no improvement in performance is likely to be found with experience.

B. The level of development of the child.

It is suggested that the effects of experience will be more marked the more advanced the level of development, but that a limit will be reached beyond which no further improvement will be possible.

i) At a lower level of development, no improvement with experience will occur. This would be the case in those children who show non-conservation on all the tests, in spite of their experiences on the previous tests.

ii) At a slightly more advanced level, some improvement with experience may occur, but only if the operational structures required for the later tests are the same as those required for the earlier tests.

iii) At a more advanced level of development, improvement with experience may occur even when the operational structures required for the later tests are slightly more advanced than those required for the earlier tests.

The general tendency for improvements in performance to occur with order of presentation could be explained in terms of both ii) and iii) above.

iv) At very advanced levels of development, it is possible that experience on earlier tests may lead to improvement on tests which require entirely new operational structures for their solution.

This would explain why a few children who show initial non-conservation responses on the early tests are finally able to achieve conservation on the most difficult tests.

v) Beyond a certain level of development, no further improvement would be possible, since from the beginning the child would be able to solve all the problems. This would be the case in those children who show conservation on all the tests.

This gradation would mark a continuous development and intermediate steps between each of the above would be expected to occur.

If the effects of order depend on the interaction of A and B as outlined above, our results on the relative difficulty of the tests may be interpreted as follows:

1. The fact that a gradual improvement with order of presentation is shown for the tests on quantity, length and weight suggests that these tests depend on the same basic structures of thought. This is consistent with Piaget's view that the solution of these problems depends on concrete operational structures.

2. The fact that the tests on area and volume are the most difficult tests, in spite of the fact that they were administered at the end of the series of tests,

suggests that these tests may depend on a completely new set of operational structures. This is consistent with Piaget's view that conservation of volume depends on formal operational structures, and is consistent with his theory that conservation of complementary area in the present test depends on more advanced concrete operational structures which are developed only at Stage III B, but not with his actual findings on this test. This point is discussed in further detail elsewhere (see p.284).

3. The question of whether the test on number depends on formal or concrete operations is not immediately clear from the results. In the Hermannsburg group, where it was presented first, it was as difficult as the formal operational test; in the Elcho group, where it was presented last, it was as easy as the concrete operational tests. However, an examination of the relative order of difficulty for this test in the older Hermannsburg children (see Figure 10) indicates that conservation of number must depend on concrete operational structures, since this test is easier for these children than the tests on area and volume, even though this is the first test in the series and the tests on area and volume are at the end of the series. This is consistent with Piaget's view that conservation of number depends on concrete operational structures and is found at the same time as conservation of quantity and length.

4. The fact that the test on length is relatively more difficult for the older than for the younger children

in both groups cannot be explained in terms of the suggested effects of experience depending on the interaction of the particular tests involved and the child's level of development. This problem will be discussed later in relation to the possible effects of the Cuissenaire teaching method on the younger children.

The Development of Conservation of Quantity, Weight and Volume

Piaget and Inhelder (1962) have postulated an invariant order in the development of quantity, weight and volume. The invariant order between quantity and weight was not confirmed by our results, but the almost invariant conservation of volume after that of quantity and weight was confirmed.

It is suggested that the reversal in the order of development of quantity and weight from the invariant order postulated may be due to the effects of experience on the tests, such that the children were able to perform better on the test on weight because of their experience on the previous tests. The findings of Smedslund (1959) and Inhelder and Vinh-Bang, reported by Piaget and Inhelder (1962), suggest that the interval between the achievement of conservation of quantity and weight may be very short. It is therefore reasonable to suppose that very little further experience is necessary for the development of conservation of weight. Because of the particular background of the Aboriginal children, and their initial unfamiliarity with the test situations, the effects of experience on the previous tests may be more marked than in the case of European children.

The test on weight appeared to be relatively more difficult for the younger than for the older children, particularly in the Elcho group (see Figures 9 and 10).

It was also noted in the analysis of the non-scale types (see p.239) that a number of deviations showing less advanced responses than expected were found in the test on weight, suggesting that experience on the previous tests does not necessarily lead to improved performances on this test. This suggests that conservation of weight may depend on more advanced structures than are required for conservation of quantity and length.

The fact that conservation of volume was one of the most difficult tests in both groups, in spite of the fact that it was administered at the end of the series of tests, gives strong support to Piaget and Inhelder's view that conservation of volume depends on formal operational structures and is found much later than conservation of quantity and weight.

2. Differences in Development between Aboriginal and European Children and Between the Elcho and Hermannsburg Groups, and Environmental Influences

Differences in the Development of Conservation in Aboriginal and European Children

Conservation was found to develop much later in Aboriginal children than has been found in European children by Piaget and by other investigators. This finding is not inconsistent with Piaget's theory of development, since he assumes that development occurs as a result of the child's interaction with the environment, and he has stated that the age at which a particular stage of development is reached may vary widely in different cultures (Tanner and Inhelder [1960]). The extreme differences in the environmental backgrounds of Aboriginal and European children would therefore be expected to result in differences in conceptual development.

The main differences between the development of conservation in Aboriginal and European children were as follows:

i) In European children conservation of quantity, length, number and area has been found at about seven years, conservation of weight at about eight years, and conservation of volume at about twelve years. In this study of Aboriginal children conservation was not generally found before about eleven years on any of the tests except length, where a number of children from about nine years showed conservation. Conservation of area and volume was found in only a small proportion of the children even at the older age levels, while non-conservation was found on all the tests in a number of cases even up to 15 years. This suggests that in some cases conservation may not be achieved at all.

ii) The age at which conservation was achieved showed greater variability in Aboriginal children than has been reported for European children.

iii) There was not a uniform increase with age in the number of Aboriginal children achieving conservation. For example, more children at nine years than at thirteen or fourteen years achieved conservation in the Hermannsburg group.

i) Later Development of Conservation.

The later development of conservation in Aboriginal children is clearly due in part or in whole to their cultural and environmental background.

In Chapter IV it has been pointed out that the traditional tribal life of the Aborigines was extremely simple. They developed no agriculture and no trade or barter systems. Their material possessions were few. Their activities were mainly confined to hunting and gathering, and participation in religious rituals and ceremonies. Their language contains few abstract and general terms, there are no terms for numbers beyond four or five, and there are no precise terms for comparison, measurement or division.

In such an environment there is no need and no stimulus for the development of concepts of conservation. A perceptual judgement of quantity is generally sufficient, and is probably never questioned. The materials available in the culture do not encourage the notion of precise quantities. For example, utensils are not normally used for cooking, and foodstuffs are not stored in containers which would suggest comparisons of quantities. The customs of the Aborigines similarly do not require precise judgements of quantity.

It is therefore suggested that the later development of conservation in Aboriginal children is due to:

a) The fact that concepts of precise measure are not necessary in the Aboriginal culture, there are no linguistic terms available to express these concepts, and consequently there is no encouragement to develop conservation.

b) The fact that their material possessions are very limited, and they do not have any opportunity for handling or manipulating the kinds of objects or experiencing the kinds of situations which would be most likely to lead to the development of conservation. Such experiences would include the handling of toys and household objects and the constructive play activities which are common to the European child but which are almost entirely lacking in the play of the Aboriginal child.

ii) Variability in Performance.

The greater variability in individual performance at the same ages in Aboriginal children may also be related to environmental factors. In the European culture the environment of all children is to a large extent standardised by schooling from the age of about five years. This could account for the fact that concepts such as conservation are normally found within a fairly narrow age range, since the school environment would provide for all children at about the same age the type of experiences necessary for the development of conservation. Inhelder's statement that refugee children who had not had normal schooling showed initial non-conservation at a much later age than would be expected supports this view (Tanner and Inhelder [1956] p.90).

While all the Aboriginal children tested started school at the same age, the effects of schooling would be determined by the total environmental conditions. It is suggested that the effects of schooling are not the same for Aboriginal children as for European children for the following reasons:

1. The limited experiences available in the Aboriginal environment probably means that Aboriginal children starting school have not acquired the same stock of knowledge and experience or reached the same stage of development as European children at a comparable age.

2. The school experiences of the European child are designed to meet the stage of development the child has already reached, and is a continuation of the types of experiences and training most children acquire in their own homes. Aboriginal children, on the contrary, have had no preparation for the kinds of experience and training provided by the school, and the situation is completely new and unfamiliar to them. It would therefore be much more difficult for them to understand and benefit from schooling, and their development would be much slower.

This can probably best be understood in terms of Hunt's (1961) 'match' hypothesis. In the case of

European children, there is an optimum match between the stage of development reached and the new experiences which are encountered. Development is therefore rapid. In the case of Aboriginal children there is no match between the stage of development reached and the new experiences. The children are to a large extent unable to benefit from their new experiences, since they are unable to assimilate them to their previous experiences and therefore to accommodate to them. The gap is too wide. Development therefore proceeds very slowly.

Under such circumstances the rate of development will depend largely on the individual child's ability to cope with his experiences, and differences in the rate of development will vary widely from child to child. A bright child of 9 or 10 years may achieve conservation, while a dull child of 15 may not, and perhaps never will. The extent to which intelligence may influence development is discussed in a later section.

iii) Lack of Uniform Progression with Age.

The failure to show a uniform increase in conservation with age was found mainly in the Hermannsburg group. This question is discussed below.

Differences Between the Elcho and Hermannsburg Groups

Three main differences were found between the performances of the Elcho and Hermannsburg groups.

i) The test on number was one of the easiest tests in the Elcho group and one of the most difficult tests in the Hermannsburg group.

This test was presented in a different order in the two groups, and this difference has been discussed in connection with the effects of order of presentation (see p.292).

ii) The test on volume was relatively more difficult for the Hermannsburg group than for the Elcho group.

This difference may be related to environmental differences between the two groups.

The Elcho group lived next to the sea, in an area of heavy summer rainfall.

The Hermannsburg group lived in a semi-desert area where water was scarce, and there were no permanent open sources of water near the mission.

The problem of conservation of volume depended on the displacement of water. It is probable that the Elcho children would have become more familiar with water in their play activities, and this could have helped them to understand the problem of conservation in this situation.

The difference between the Elcho and Hermannsburg groups could not be due to the failure of the Hermannsburg children to understand the principle of displacement, since they showed the same initial understanding of the problem as the Elcho group. It is therefore suggested that it was the cumulative effects of many experiences of displacement of water that helped the Elcho children to develop conservation of volume.

This is consistent with Piaget's view that development is based on the child's interaction with the environment, and proceeds slowly and continuously as a result of a number of separate encounters and experiences.

iii) The Elcho group showed a fairly clear transition point at about 11 or 12 years for the development of conservation, while the Hermannsburg group showed only a very gradual and non-uniform improvement from about 9 to 14 years. The younger Hermannsburg children therefore tended to perform better than the corresponding Elcho children, while the older Elcho children tended to perform better than the corresponding Hermannsburg children.

It is suggested that differences in the educational backgrounds of the children may account for these differences.

1. Differences between the older children.

In the Elcho group, there were fewer children in the older age groups. This was partly a result of selection, since a shortage of teaching staff in the past resulted in a number of children being allowed to leave the school. Those who left were mainly children who were not progressing very well or who were behaviour problems, the brighter or more promising children tending to stay on (see p.148).

This has resulted in smaller classes of selected children at the advanced age levels, which has enabled closer contact between the teacher and pupils, and more individual attention for each child. A number of the older children were also taking courses with the correspondence school of South Australia (see Appendix 2). This gave them more incentive to work. The general impression of the school at Elcho was that more emphasis was placed on academic work, and the older children frequently stayed on in the school till quite late in the afternoon doing extra work or exercises. This was in contrast to the Hermannsburg school, where more emphasis seemed to be placed on sport and craftwork.

In the Hermannsburg group all the children up to 15 years were obliged to attend the school. This resulted in bigger classes at the older age levels than in the Elcho group. Some of the older children apparently resented having to attend school, and it is understood that this sometimes led to difficulties in the classes.

2. Differences between the younger children.

While there had recently been increases in the teaching staff and equipment at both schools, discussions with the teachers suggested that at Elcho these improvements had not yet had time to show any results, while at Hermannsburg the effects of these improvements were already evident in the Grade 3 class, which included most of the 9 and 10 year old children tested.

The differences between the younger and older children in the two groups may therefore have been due to the fact that in the Elcho group the educational circumstances tended to favour the older rather than the younger children, leading to marked improvements in performance at about 11 to 12 years, while in the Hermannsburg group the educational circumstances operated in the reverse direction, leading to a considerable overlap of performance from about 9 to 14 years.

The Effects of the Cuissenaire Teaching Materials

The test on length was found to be relatively more difficult for the older than for the younger children in both groups. This difference was particularly marked in the Elcho group.

The younger children in both groups had had experience on the Cuissenaire teaching materials, while the older children had not. The Cuissenaire teaching method is based directly on comparisons of the length of different coloured rods. It is therefore suggested that the difference in the relative difficulty of length is due to the influence of the Cuissenaire teaching method on the younger children.

The fact that it was only in the case of length that the relative difficulty of the tests varied from younger to older children suggests that the effects of Cuissenaire are fairly restricted. It did not appear to have very much effect on the younger children's performance on the test on number in either group.

In the Hermannsburg group the particularly good performance of the nine year old group on the test on area seems to be due to the influence of Cuissenaire, since this group also performed particularly well on length. However, none of these children succeeded on the first test on number. This suggests that Cuissenaire experience does not necessarily lead to an understanding of conservation of number, but it may lay the basis for the development of this concept.

Cuissenaire experience seems to have less effect on the conservation of quantity, weight and volume. The nine year old Hermannsburg group showed poor performances on these tests, particularly quantity and volume, in spite of their very good performances on length and area. These findings tend to support the view that conservation of length and area may depend on a separate schema of operations to that required for quantity, weight and volume, and these schemas may be to some extent independent in their development.

Different Effects of Cuissenaire on Elcho and Hermannsburg Children

The Elcho children from 8 to 10 years had generally had 2 to 3 years experience on Cuissenaire teaching materials, while the Hermannsburg group had had only nine months. Nevertheless, the effects of this experience seemed to be more marked in the Hermannsburg group than in the Elcho group. The Hermannsburg group showed better performances on length, and while several of the 9 and 10 year old Hermannsburg children succeeded on area, none of the Elcho children at these ages did.

The only reasons which can be suggested to explain this are the following:

1. It is understood that different methods were used in the two groups in the presentation of the Cuissenaire materials. It may be that the method of presentation used at Hermannsburg was more favourable to the development of concepts of conservation.

2. The Hermannsburg group may have had a wider experience of different activity materials, and because of this were able to benefit more from their experience with the Cuissenaire materials.

3. In the Hermannsburg group the part-blood children were found to perform significantly better than the full-blood. It may be that part-blood children in general have a greater potential for intellectual development, and are able to benefit more rapidly when given favourable opportunities for development, such as are provided by the Cuissenaire teaching materials. This would explain why it was only in the younger group that the presence of the part-blood children led to better performances as compared with the Elcho group.

4. The better environmental background of the Hermannsburg children may have provided more favourable conditions for the children to benefit from experience on the teaching materials. These better conditions would include:

a) Generally better health and nutrition.

b) Their contacts with Alice Springs and with tourists and other visitors to the mission may have provided the Hermannsburg children with more varied experiences and encounters which would have laid a better basis for later development.

c) The longer and closer contact of the Hermannsburg people with the mission and with European culture and values may have led to changes in attitudes and values which were more favourable to intellectual development.

The effects of the Cuissenaire teaching materials on conceptual development clearly requires more detailed investigation. The possibility that these effects may vary according to the method of presentation or according to other experiences requires checking. It is also necessary to determine whether development induced in one area, such as length, will also lead to development in other areas, such as quantity and weight, and whether this experience will also lead to success on more complex problems, such as the understanding of measurement and sub-division.

This question will be referred to again in the final discussion on the educational implications of our findings.

3. The Factors of Intelligence and Maturation in Development

Intelligence

Our results indicate that some children are able to progress much more rapidly with experience than other children, even though they may appear to be at the same stage of development initially. In some children transitional reactions will persist over several tests, while in other children a rapid progress from non-conservation and transitional reactions to conservation may occur within a single testing period.

Because of the limited possessions and the communal life of the group as a whole, there is little variation in the individual environmental backgrounds of the children. Nevertheless, marked differences are found in children of the same age with regard to the stage of development reached and the rapidity of development from one stage to the next.

It is therefore suggested that these differences are due to differences in innate intellectual potential which determines the extent to which the individual can benefit from his experiences and the rate at which he will progress.

The possibility that it is not so much the stage of development reached which may give an indication of innate intellectual potential, but the rapidity of development from one stage to the next, has important implications for the measurement of intelligence, and suggests possible applications of Piaget's techniques for the measurement of intellectual potential. This point has been made by Inhelder (Tanner and Inhelder [1956]), and also by Vygotsky (1962) and Luria (1961) (see discussion Chapter I, p.62-3).

Maturation

The role of maturation in conceptual development has been discussed in Chapter I.

Our main findings relevant to this question are:

1. Conservation develops much later in Aboriginal children than in European children, suggesting that this development may be influenced by the cultural environment.

2. Aboriginal children who show initial non-conservation may, in the same testing session, or within a period of a few weeks, develop conservation.

3. Many Aboriginal children up to the age of 15 years do not show any sign of developing conservation, even after being confronted with a series of problems over a period of about two months, and being closely questioned on the problems.

4. A few children showed initial non-conservation responses on the concrete operational tests, and then went on to achieve conservation in the more advanced concrete and formal operational tests.

This last finding seems to be inexplicable in terms of Piaget's theory. While Piaget does not specify precisely how long it should take for the child to progress from the pre-operational to the formal operational level, it would seem fairly clear that his theory would demand a minimum of two to three years for this progress to be achieved. And yet a few of our children appeared to progress from pre-operational to formal thought in a period of a few weeks.

This could be due simply to problems of the classification of responses. There are two possibilities:

1. Conservation of volume and area may not necessarily depend on formal structures or on more advanced concrete operational structures, but may depend on the same thought structures as are required for conservation of quantity, weight and number, but are normally developed a little later because of the particular difficulties associated with the conceptualisation of area and volume. Piaget in fact gives this explanation for the later development of conservation of weight (Inhelder and Piaget [1958]).

2. The conservation of volume and area found in these cases was not true operational conservation, but an intuitive conservation, probably arising from the children's experiences on the other tests. Piaget has in fact used this argument to explain why he found conservation of complementary area at seven years (Stage III A) and not at Stage III B as expected on theoretical grounds.

However, these cases were all very clear and definite cases of conservation, and the children were able to give adequate explanations for their conservation answers. If these cases were not true conservation, then there is no guarantee that any of the other cases classified as conservation were true conservation cases.

Assuming that these cases were true conservation, and that conservation of volume depends on formal operations, the finding that children may progress from pre-operational to formal operational thought in a period of a few weeks has important implications for the role of maturation in development.

There would seem to be three possible explanations.

1. In these cases the maturational basis for formal operations may already have been present, but neither concrete nor formal operations had been developed through lack of experience. Under these circumstances only a few decisive experiences were necessary to achieve both concrete and formal operations.

While this explanation would seem to give too great a role to maturation, Inhelder's comments with regard to refugee children suggest that this explanation might be acceptable to Piaget (Tanner and Inhelder [1956]).

2. This development need not necessarily depend only on maturation. These children may have acquired the experiences necessary for the development of concrete and formal operations, or may even have already developed concrete and formal operations, but because of the unfamiliarity of the test situation these were not immediately applied in this case. This possibility is supported by the fact that two of the children who showed this development had had experience with the Cuissenaire materials. This experience may have laid the basis for concrete and formal operations. It is perhaps significant that in one case conservation occurred in all tests following that of length, which seemed to be most directly influenced by experience with Cuissenaire materials.

3. The rate of development may be determined by the intellectual potential of the individual rather than by

maturation. Some children may therefore be able to progress much more rapidly from pre-operational to formal operational thought on the basis of much fewer experiences because of their superior genetic intellectual potential in terms of particular characteristics of neural structure or metabolism.

While our findings do not provide conclusive evidence as to the role of maturation in development, they do suggest the following conclusions:

1. Intellectual development cannot be determined solely by maturation, since differences in cultural environment result in differences in the rate of development.

2. Some of our results suggest that there may be some kind of maturational 'readiness' for development, such that at a certain stage children can develop very rapidly on the basis of only a few experiences. On the other hand, other children at a much later age do not show such a 'readiness' for development, and show no improvement in performance after experience over the whole series of tests.

Two possible interpretations may be suggested.

i) The 'readiness' for development may depend not on maturation but on:

a) Previous experiences

b) Genetic intellectual potential

c) A combination or interaction of a) and b).

ii) There may be a critical period of maturational readiness, such that if during this period appropriate experiences for development are not acquired, this development will no longer be possible, or will be much more difficult to achieve. This could explain why some of the older children show no sign of developing conservation in spite of their experiences and questioning on the test situations. The extent to which an individual can overcome the lack of experience during the critical period, or can make use of very limited experiences, could depend on his intellectual potential, some individuals being able to overcome this handicap while others are not.

This possibility, if confirmed, would have extremely important implications for the education, training, and capabilities of people from various cultural backgrounds. This interpretation could be related to Hebb's distinction between primary and secondary learning, and the finding that certain types of learning which are very rapid at early ages become more difficult at later ages. Hunt (1961) has discussed the question of critical periods, which have been demonstrated in certain animals, and the implications of such critical periods in development. These implications will be referred to again in the final chapter.

4. The Differences Between the Full-Blood and the Part-Blood Children and the Question of Racial Differences in Intelligence

From the significant differences between the full-blood and the part-blood children in the Hermannsburg group it can be concluded that those children in this particular sample who have some European ancestry perform better than those children who have no European ancestry.

Since the environment and schooling of all the children on the mission is the same, these differences cannot be attributed to environmental differences between the groups, but must be attributed to genetic differences.

Family Differences in Performance

In this particular sample there is a high degree of interrelationship between the children tested. Many of the part-blood children are related, and many derive from the same European ancestry. Similarly, many of the full-blood children are related. It is therefore possible that the differences between the part-blood and the full-blood children are due to family differences in intelligence. The superior performance of the part-blood children may be due to one or two large family groups with some European ancestry. Such family differences in intelligence may or may not be related to the presence or absence of European ancestry. If it is related to European ancestry, it may be by chance that this ancestry provided a particularly favourable genetic potential for intellectual development.

Family differences in intelligence were in fact observed. It was noted that in some cases the children from one particular family tended to do well on the tests, while children from another tended to be generally unsuccessful. The number of children involved was too small to enable any test of family differences to be undertaken, and the factor of age differences would make such a study difficult. Precise details were not obtained on family relations, but family names indicated family groups and in many cases brothers and sisters were known from personal knowledge of the children.

Superior and inferior families seemed to occur in both the full-blood and the part-blood groups, and considerable overlap in ability between the full-blood and the part-blood children was observed. Of the six children in the Hermannsburg group who were classified at the conservation level on all of the tests, two were full-blood children. Some of the full-blood children therefore produced performances equal to the best performances of the part-blood group. Of six fifteen-year old children who achieved conservation on only one test or on none of the tests, three were part-blood and three were full-blood.

Comparison with Elcho Group

The comparison of the part-blood Hermannsburg children with the full-blood Elcho children indicates that at the younger levels the differences are comparable to those between the part-blood and the full-blood Hermannsburg children, but that at the older age level the performances of the Elcho children approach those of the part-blood children, and on two of the tests is superior to that of the part-blood children.

It is very difficult to draw any conclusions from this comparison, since there were other clear differences between the Elcho and the Hermannsburg group. One of the tests on which the Elcho children showed a superior performance was that on number, which was presented in a different order in the two groups, and whose relative difficulty was completely reversed according to the order in which it was presented. The other test on which the Elcho children showed a superior performance was volume. The relative difficulty of this test was also different in the two groups, and this difference has been discussed in relation to environmental differences between the groups.

There was also a difference between the relative performance of the younger and older children in the two groups, the younger Hermannsburg children performing better than the younger Elcho children, while the older Elcho children performed better than the older Hermannsburg children. It is possible that the better performance of the older Elcho children as compared with the full-blood Hermannsburg childrem may be due to this difference, which has been discussed in relation to differences in the educational background and circumstances of the two groups.

A further complicating factor is that some of the Elcho children were known to have a certain degree of Malay ancestry, and the group was not therefore a pure full-blood Aboriginal group. It is also possible that there might be a further unknown mixture of Malay ancestry among the Elcho children (see Chapter IV). The family with known Malay ancestry was a particularly successful family; the children had generally done well at school and many of the adults held responsible positions on the mission. The children of this family tended to do well on the tests. This fact in itself is not of great significance, but taken together with the differences found between the full-blood and the part-blood children at Hermannsburg, it lends support to the view that superior performances may be associated with non-Aboriginal ancestry.

Possible Differences in the Environmental Backgrounds of the Part-Blood and the Full-Blood Children

It has been stated that there was no difference between the environmental backgrounds of the full-blood and part-blood Hermannsburg children. So far as is known to the writer, this statement is correct. The majority of the part-blood children at Hermannsburg trace their European ancestry back three or four generations. It is understood that in most cases there was no contact between the European ancestor and his offspring. The part-blood children were accepted and brought up as full members of the tribe, and were treated no differently from other children.

It is possible that in a few cases there may be some history of contact between the part-blood child and his European father, or a history of prolonged contact between the mother of such a child and the European father. That is, an Aboriginal woman may have lived with an European for some time, and so have come into closer contact with a European way of life. Such a situation did not occur on the Hermannsburg mission, but may have occurred in Alice Springs or in other neighbouring areas, and the families or children may later have gone to live at Hermannsburg. However, it is not known whether any of the families of the children tested did have any history of such contact in the past. Certainly none of the children tested had themselves had this kind of contact with Europeans, and their present environment and contact was no different to that of the full-blood children.

It could be argued that if such past contacts did occur in the history of the children's families, they could have resulted in a difference in the attitudes of the parents or grandparents of the present part-blood children, which resulted in a difference in upbringing between these part-blood children and the full-blood children.

In our culture parental attitudes can be crucial to intellectual development. The child who is supplied with a variety of toy materials and books, who is actively encouraged to learn and is able to ask questions and to have problems explained to him, is likely to develop much more quickly than a child who lacks these advantages, regardless of genetic intellectual potential. In our society the child spends a great deal of time alone with his mother, and the mother's attitude and teaching therefore have a considerable influence on him.

This situation is not found in the Aboriginal society. The environment of all the children living at Hermannsburg was virtually identical, and whether the children lived in a two-roomed aluminium house or a humpy, the furniture and possessions of the family would be equally limited. The communal life of the group meant that children spent little time alone with their parents. The young children would accompany their mothers, who spent most of their time in the company of other women, and they were often looked after by other relatives or by older sisters. Once they were old enough to be on their own, they would spend their time playing with other children. Even if a mother did devote considerable care and attention to her child, she would not be in a position to supply the child with the kinds of material possessions that would be most likely to promote intellectual development. It is not the custom of Aboriginal people to encourage children to ask questions or to explain or discuss problems with them, and they are usually taught only songs, stories or practical skills. It is unlikely that any of the part-blood parents would have acted any differently in this respect.

Parental attitudes and intelligence would therefore have much less effect on the upbringing of the children in an Aboriginal community than in a European community, and it would seem unlikely that differences in attitudes or upbringing in the parents, grandparents, or great grandparents of the present part-blood children could have led to any real differences between the upbringing and environment of the part-blood and the full-blood children tested, even assuming that such differences did occur.

A few of the children at Hermannsburg may not have lived on the mission all their lives, but may have spent some time in Alice Springs or on neighbouring settlements or properties. However, there is no reason to believe that these environments would be markedly different from the Hermannsburg environment, or that it was only the part-blood children who had had such experience of other environments.

In Alice Springs the children would have had more opportunity to visit the town and the shops, and may have had more chance of becoming familiar with a greater variety of European products and gadgets. However, the housing conditions in the Aboriginal settlement here would not have been very different to those at Hermannsburg, and the material possessions of the people would not necessarily be greater. A large proportion of the Aboriginal population living at Alice Springs was unemployed, and the standard of living here was not higher than at Hermannsburg.

There is therefore no clear evidence of any environmental differences between the part-blood and the full-blood children, and all the available evidence points to an environment which is extremely similar for all the children tested.

The Question of Possible Racial Differences in Intelligence

The controversial question of racial differences in intelligence has been referred to earlier (see Chapter I). It has been pointed out that a number of scientists have questioned the implication of the U.N.E.S.C.O. Statement on Race and Race Differences that there are no racial differences in mental characteristics. The view of these critics can perhaps best be summed up by Morant's statement: 'It seems to be impossible to evade the conclusion that some racial differences in mental characters must be expected' (Morant [1956] p.320).

If we accept this view, a reasonable interpretation of the significant differences found between the part-blood and the full-blood children would be that these differences are a result of racial differences in intelligence between Aborigines and Europeans, such that the part-blood children had a higher probability of inheriting a higher intellectual potential.

Most writers have emphasised that while the average mental capacities of two races may differ, the range of mental capacities will show a considerable overlap between the extreme groups, and variation within groups may be almost as great as variation between groups. Morant states: 'It is unlikely that there are any racial differences in mentality which make an absolute distinction between all members of one population and all members of any other' (ibid., p.323).

Our findings are consistent with this view. While more of the part-blood children performed better as compared with the full-blood children, there was a considerable overlap between the performances of the two groups. Some of the performances of the full-blood children were as good as the best performances of the part-blood children, while some of the part-blood performances were as poor as the poorest full-blood performances.

Thus while our results may be interpreted in terms of racial differences in average intelligence between Aborigines and Europeans, they cannot be interpreted in terms of absolute differences between the intelligence of European and Aborigines. Individual performance can not be predicted on the basis of Aboriginal or European ancestry, nor can distinctions be made between part-blood and full-blood children on the basis of their performance on the tests.

Thus whether the significant differences found between part-blood and full-blood children are interpreted in terms of racial differences in average intelligence or not, this question has no bearing on the practical problems of the education and training of Aborigines. Individual full-blood Aboriginals may be as capable of profiting from education and training as part-blood or European children. This question is to be discussed in further detail later. However, it is appropriate at this point to caution against possible unwarranted implications which may be attached to these results.

The Probability of Racial Differences in Intelligence Between Aborigines and Europeans

If racial differences in intelligence are to be expected, it is likely that they would be most marked in groups which have developed in isolation. The exact origin and history of the Australian Aboriginal is unknown. Abbie (1960a) believes that the physical and cultural homogeneity of the Aborigines throughout Australia suggests a single origin from a relatively small group with a limited gene pool. He also believes that the absence of any marked differences between groups from different areas is evidence that there was a minimum of admixture with other racial groups before the European occupation of the country (Abbie [1960b]). Racial differences between Aborigines and other groups would therefore be expected to occur as a result of several factors.

1. If the original group was small, the present population would have been derived from a relatively limited gene pool, and chance variations in the original group would have become normal characteristics of the present population as a result of genetic drift. Thus the present Aborigines may differ from other groups in certain specific characteristics, or in the distribution of such characteristics.

2. The extreme environmental conditions under which the Aboriginals lived, and their restricted diet, may have led to metabolic changes affecting the genetic constitution of the race as a whole.

3. The factor of natural selection may have operated differently in the Aboriginal culture as compared with other cultures. For example, one of the characteristics of the Aboriginal society is its emphasis on conformity, tradition, and convention. In our society, high intelligence is often associated with initiative and originality. In the Aboriginal society these characters were not desirable. Polygamy was practised,

and the number of wives a man possessed was some indication of his status and success. The non-conformist would therefore be less likely to leave a large number of descendants, and probably more likely to be involved in fights and conflicts with the tribe, and therefore to meet an early death.

This argument is purely conjectural. An opposite argument could be put forward that the more intelligent individual would take care not to become involved in fights, and to collect as large a number of wives as possible. However, the point at present being made is that adaptability to the Aboriginal culture may not have depended on intelligence as we understand it and measure it in our society, and that high intelligence associated with originality and initiative may in fact have been non-adaptive and been to some extent selected out of the community. In a small group of people and operating over an extensive period of time, this factor could have tended to lower the average intelligence of the group as a whole.

CHAPTER IX

CRITICAL DISCUSSION OF PIAGET'S THEORY

In this chapter a critical analysis of Piaget's theory will be made. This will be based on the problems raised by the Piaget studies and by our own study. As suggested in Chapter III, these problems can be related to three main questions, which are interrelated. These are:

1. The Continuity or Discontinuity of the Stages of Development.
2. The Intuitive Stage of Development.
3. The Interrelationships Between Performance on Different Tests.

An attempt will be made to clarify the problems that have been raised and to point to those aspects which require further investigation, and alternative interpretations of some of the findings reported will be considered.

1. The Continuity or Discontinuity of the Stages of Development

Piaget and Inhelder (Tanner and Inhelder [1960]) recognise both continuity and discontinuity in development, but they regard the stages as discontinuous in that they involve a sudden reorganisation leading to an abrupt change in behaviour, which marks the appearance of a new and qualitatively different form of thought to that found at the previous level. While Piaget (Inhelder and Piaget [1958] p.249) states that concrete thought, once achieved, is not immediately generalized to all physical properties, it is nevertheless considered to affect the child's thought over a wide range of problems and situations.

The accumulated evidence from a number of studies indicates that the stages of development are not as clear cut as Piaget originally thought. For example, Piaget (1960 [p.65]) quotes Greco's finding that the ability to conserve small numbers is not immediately extended to all numbers, but is only gradually applied to larger and larger numerical sets. This progress he has termed 'progressive arithmetization'.

The continuity of the stages of development is clearly illustrated in the test on area, where initial conservation can break down at various points as the number of blocks on the two fields is increased, thus increasing the perceptual illusion of a greater expanse of green grass in the one field as compared to the other. This continuity is also evident in our supplementary procedure, where we continued adding houses to the field that the child judged to have more grass until he reversed his judgement. A continuous gradation was found for the point at which the children reversed their judgements.

In the test on weight, we found that of a number of children who showed clear conservation, about a half reverted to non-conservation when faced with an apparent contradiction of conservation, while the other half persisted in their conservation judgements and found some other solution to explain the apparent contradiction.

Previous to this contradiction the conservation responses of both groups of children were indistinguishable. This is exactly parallel to Smedslund's (1961, Part III) finding that of a group of children who showed indistinguishable conservation responses, about half were resistant to apparent contradictory evidence, while the other half were not. These findings indicate a continuity in the degrees of conservation achieved; in some cases the notion of conservation was so strong that some other explanation had to be found for the apparent contradiction, and in other cases conservation broke down at the first indication of contradictory evidence.

These findings appear to conflict with Piaget's earlier writings, which tend to see the stage of concrete thinking as marking a sudden qualitative change, which is immediately apparent in all situations. Later writings and statements suggest some revision of this view, but it is necessary for this problem to be clarified and it's implications analysed.

The question of the continuity of development is related to many of the problems which have been raised by the Piaget studies, including those of the distinction between operational and intuitive solutions and the question of the interrelationships between performance on different tests which are discussed below. It is also related to the question of variations in performance according to the particular test situation, which has been raised by a number of investigators and by our own findings. The study of Frank reported by Bruner (1964) is particularly important in showing the extent to which the test situation can influence performance. Further studies of this problem are clearly required. This question will be discussed in further detail in the final section of this chapter, when we will consider Zimiles attempt to explain the findings of Wohlwill and Lowe (1962) in terms of a continuous process of development.

2. The Intuitive Stage of Development

A great deal of confusion seems to have been caused by the failure of many research workers fully to recognise Piaget's intuitive or transitional stage of development. That is, a stage when correct answers may be achieved before the concrete operational stage is reached. Many workers appear to assume that any correct solution indicates the presence of operational thought, and that if they are able to induce apparent operational responses in a child they have induced concrete operational thinking. This has led to conflicting reports as to the age at which concrete operational thought is found and the extent to which it can be produced by training and experience. Goodnow (1962) has made the important point that there is no sense in comparing results from different studies unless there is some agreement on the criteria of success. These criteria are at two levels. First, with regard to the percentage of children passing a given test at certain critical ages. Second, and more importantly, with regard to the criteria of success for individual cases. Goodnow favours Piaget's definition of operational concepts in terms of logical necessity and resistance to suggestion and apparent contradiction.

Piaget's own treatment of the stage of intuitive thought is in many cases unsatisfactory. For example, in his test on area he explained the discrepancy between the children's performances on the conservation of complementary area in two different situations in terms of whether the solution was operational or intuitive (see pp.105-6), but in practice it was not possible to distinguish between these two solutions, and the distinction was made on the basis of theoretical considerations.

A further difficulty illustrated by the test on area is that it is impossible to distinguish between the apparent conservation responses of those children whose conservation breaks down when they reach 15 or 16 houses, and those children whose conservation will continue regardless of the number of houses involved. Of those whose conservation responses persisted up to 20 or 25 houses, how could one be sure that this conservation would not break down at a later point, say at 30 houses? Piaget is undoubtedly correct in saying that at a certain point the child will understand that no matter how many houses are involved, so long as the number of houses is equal, the remaining areas must be the same. The difficulty is to determine at what point this occurs, and which children have reached this understanding and which have not.

A clarification of this problem is required, and certain steps that appear to be necessary for such a clarification may be suggested.

1. A recognition of the fact that a correct response does not necessarily indicate the presence of Piaget's concrete operational stage of development. While this may seem to be very obvious, it has in fact been ignored by a number of workers.

2. Piaget's notion of intuitive thought must be extended, and a greater emphasis placed on the continuity and gradualness of the development of thought. It must be recognised that operational thought is not achieved suddenly and immediately extended to all areas, but is at first recognised in a few special cases only, and then gradually extended to wider and wider areas.

3. Research on Piaget's concepts must emphasise the strength and stability of concepts. That is to say, the research problem should not be exclusively concerned with how early or at what age a particular concept can be induced or achieved, but if such a concept is induced, how resistent it will be to extinction, and whether it will withstand apparent contradictions. While Piaget himself has never deviated from this position, it is seldom clearly recognised by other investigators in this area. The term operational thinking should be reserved for those concepts which cannot be extinguished under any reasonable circumstances, and the conditions and stages under which operational thinking develops, and the ease with which it can be broken down at each stage, should be fully investigated.

3. Interrelationships Between Performance on Different Tests

A number of research workers have raised the problem of the interrelationships between performance on different tests. Dodwell (1960) and Hyde (1959) have pointed to the lack of consistency in children's performances on tests on number, some children operating at a concrete operational level on some tests, but at a pre-operational level on other tests. This has also been remarked by Lovell in a variety of studies and by Lunzer (1960a) with regard to performance on the relationship between the calculation of volume and the understanding of infinity and continuity. Goodnow (1962) has also remarked on this in relation to her subjects' performances on a combinatorial test and on conservation of volume. Woodward (1961), on the contrary, found a higher degree of consistency in her mentally sub-normal subjects, provided that a single dichotomy was made between the concrete operational level and the pre-operational level.

This problem raises the question of whether or not Piaget's stages indicate total structures which are operative over a wide area, as Piaget maintains, and is also related to the question of the continuity of development.

Our own findings indicate a high degree of consistency in the children's performances over the tests. Inconsistencies that did occur seemed to be due mainly to the effects of experience on the previous tests.

In order to clarify some of the conflicting views on this question, two points should be made:

1. The order of presentation of the tests must be taken into account when studying developmental sequences for the solution of particular problems, since the children's performances may be affected by their experience on the previous tests.

It is often assumed that Piaget believes that experience on the tests will not affect the children's later performance, since this is not due to specific learning. This seems to be a misunderstanding of Piaget. He would maintain that children cannot learn to solve the problems before they have reached a certain level of development, but there is nothing in his theory to preclude the possibility that experience on the tests may itself promote development, particularly at the transitional level. Where the order of presentation of the tests is randomised, as in most of the studies reported, there is no means of determining whether inconsistencies in the order of achievement of the concepts may be due to the effects of experience or to the absence of a sequential order of development for these concepts.

2. A distinction must be made between those tests for which Piaget clearly postulates a sequential order, such as for conservation of quantity, weight and volume, and those tests which Piaget maintains are solved at about the same time. In the first case the invariance of the order of development is essential to Piaget's theory, in the second case it is not. This point has also been made by Goodnow (1962). A number of writers (e.g.,

Dodwell [1960]), have questioned Piaget's theory of developmental sequences on the basis of tests for which Piaget has not in fact postulated an invariant order. Other writers (Wohlwill [1960] Kofsky [1966]) have themselves postulated a particular order of development based on their own interpretation of Piaget's theory, and have then evaluated Piaget's theory in terms of whether or not the results confirm this sequence.

There are two approaches which could contribute to the study of this problem:

1. A first essential would be a systematic study of order effects, since these may affect the relationships between performance on different tests.

No studies using Piaget-type techniques have in fact investigated order effects. In most of the Geneva studies, each child is tested on only one test. In those cases where a child was tested on more than one test, as in the quantity, weight and volume study, the effect of order of presentation was not investigated and this problem was not discussed. In the large-scale validation study being undertaken by Inhelder and Vinh Bang, each child is tested on only one test.[1] In the validation study being undertaken by Pinard in Montreal, the order of presentation is varied randomly according to the responses and interests of the child, at least for the younger children.[1] Neither of these validation studies will therefore provide any information on the effects of order of presentation.

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[1] Personal communications.

Studies of Piaget's concepts by other investigators have usually been limited to studies of one or two tests only. Where a series of tests have been administered, the order of presentation has usually been randomised to control for effects of order (Hyde [1959], Kofsky [1966]). Lovell, Healey and Rowland (1962) do not discuss the order of presentation or the possible effects of experience on the previous tests in their study of geometrical concepts, where a number of tests were administered to the same children. These studies therefore do not provide any information on the possible effects of order of presentation.

The learning studies of Wohlwill and Lowe (1962) and Beilin and Franklin (1962) suggest that experiences on the test situations can lead to an improvement in performance. Beilin and Franklin's findings suggest that these effects may vary according to the age and the intelligence of the child. On the other hand, the learning studies of Smedslund, Greco and Morf (reviewed by Smedslund [1959]) have shown very little improvement in performance after specific training, although the studies of Harker (1960) and Churchill (1958) have shown greater improvements. These findings suggest that order effects would not be very marked, since even with specific training little improvement in performance occurs. However, it is possible that the effects of such training may vary according to the age of the children tested, and that where no improvements in performance occurred the children tested were too young to benefit from training.

A proposal for a systematic study of order effects has been set out in Appendix 7, and this is discussed in further detail in the final chapter.

2. The Guttman scale technique could be used for the study of sequential orders in the development of certain concepts and for the study of the interrelationships between performance on different tests. Although a number of studies have made use of this technique, it has not as yet been used to full advantage. In most cases the order of presentation of the tests has been randomised, thus confounding the sequential order of development with the effects of experience. No studies have reported detailed examinations of non-scale patterns of response. The interpretations of some of the scalogram analyses carried out have also indicated some misunderstandings in the use of this technique. Kofsky (1966), for example, reports that a reproducibility co-efficient of .90 is 'not significant' because the Index of Reproducibility obtained by Green's (1956) method was below the .50 level. However, this does not necessarily indicate that the items are not scalable in terms of Guttman's criteria, but simply that this high co-efficient may be due to high minimum marginal reproducibilities rather than to the scalability of the items. Kofsky also applied some of Loevinger's homogeneity tests to her results, but questioned whether these techniques were suitable for testing for invariant order. However, she applied only Loevinger's tests for item-test (H_{it}) and inter-item (H_{ii}) homogeneity, and failed to apply the test for

homogeneity of the scale as a whole (H_t), which would correspond to Guttman's co-efficient of reproducibility. She also found that a high percentage of children showed non-scale patterns of response, but did not indicate how the non-scale types varied from the perfect scale. Our results have shown that if the majority of the non-scale types are only one off the perfect scale, a high percentage of non-scale types can occur together with high reproducibility co-efficients.

Smedslund (1964) made a study of the interrelationships between performances on a series of tests, but he reports only the inter-item associations and the number of cases for each pattern of response. He concludes that these indicate low homogeneity for the set of items as a whole. A scale analysis carried out on the score patterns which he reports in full gives a co-efficient of reproducibility (using the Goodenough method) of .86, and a plus percentage ratio of .60, which is very close to Guttman's criterion for scalability. Our results suggest that these data would also yield a fairly high figure on Loevinger's test for homogeneity (H_t).

In other studies where the scalogram technique would be suitable for the analysis of the results, such as in Lovell, Healey and Rowland's (1962) study of geometrical concepts, this technique has not been applied.

A more effective use of the scalogram technique in studies based on Piaget's tests could contribute to the study of developmental sequences and invariant orders, and the problem of the interrelationships between performance on different tests.

Alternative Explanations of These Problems

An alternative to Piaget's theory has been suggested by Zimiles (1963), who has attempted to explain Wohlwill and Lowe's (1962) findings on number in terms of a continuous development from a confused and undifferentiated concept to one of greater precision and rigour, following the theory proposed by Werner (1948).

He suggests that at first the child may have many different definitions of quantity. These would be based on perceptual cues, since initially these are the only ones available to him. Later, as he learns to count, he includes number as simply one other means of judging quantity, which is not necessarily any better than the other perceptual cues he uses. This situation would explain the conservation of 'quotité' found before conservation of quantity, reported by Greco (1962). It also explains the various results reported by Wohlwill and Lowe, since at the stage when number is regarded as a possible but not necessarily as the only way of judging quantity, apparent conservation of number may be found in some situations where the set induced by the experimenters' questions or actions, or the particular training techniques employed, directs the child's attention to number, while in other situations perceptual cues may be used to estimate quantity, particularly if these are very dominant.

Zimiles suggests that with increasing experience the child gradually discovers that perceptual cues for judging quantity lead to inconsistent results, while numerical cues lead to consistent results. He therefore relies increasingly on number, and finally number is recognised as the only consistent and rigorous method of estimating quantity and is always used.

Zimiles therefore suggests a continuous process in the development of the concept of number. Piaget's first stage would correspond to the period when the child does not recognise number as a means of estimating quantity at all. Piaget's second stage would correspond to the period where the child may recognise number as a means of estimating quantity in some situations but not in others. This would begin with the stage described by Piaget when the child is able to recognise that number implies equality when the objects compared are in one-one correspondence, but not when this one-one correspondence is broken down. The importance of number in estimating quantity would gradually be recognised in more and more situations, until the child may recognise, for example, that two groups of 20 objects are always the same number regardless of their arrangement, but when the groups are increased to 30 objects changes in the perceptual arrangements of the groups may lead to such strong perceptual contrasts that conservation will break down. Piaget's stage of concrete operations would correspond to the stage where the child finally recognises that no matter how many objects are involved, the quantities must always be the same if the numbers are equal.

There seem to be some parallels between Zimiles' explanation and Piaget's tentative description of the transition from one level of thinking to the next in terms of a probabalistic model, which is linked to game theory.

In this model Piaget (in Tanner and Inhelder [1960]) outlines certain successive strategies or steps leading to the development of conservation, based on alternate focusings on two aspects of a situation (for example, the length and the density of a row of objects), and the probability of both these aspects being focused together. This is related to game theory by suggesting that the focusing of one aspect is least costly, but also gives the lowest yield since it gives rise to inconsistent judgements depending on which aspect is focused; while the focusing of two aspects at the same time is the most costly or difficult strategy to achieve, but gives the highest yield since it achieves consistency of judgements. This model has certain weaknesses as it stands (see Flavell [1963]). However, it does seem possible that it could be developed to fit the kind of problems that Zimiles has attempted to explain.

The major weakness of the model is its dependence on probability alone. However, if this notion of probability is tied to a neuro-physiological basis, it could provide a more plausible explanation for the events it is required to fit.

The development of conservation could be explained in terms of this model as follows:

1. Non-conservation is due to the focusing of only one aspect of a situation at a time.

2. The perceptual stiuation may determine which aspect is focused. This would explain why in some situations all the children tend to make the same judgement. For, example, in our test on quantity, virtually all the children consistently judged that the long glass would have more sugar.

3. In the course of time, and possibly depending on neural factors, there would be a tendency for children to focus on the two aspects alternately. However, if the situation presents a fairly strong perceptual illusion, this tendency may be inhibited or delayed. This would be consistent with our observation in the test on quantity that in Part 2 there was a consistent tendency for the long glass to be judged to have more sugar, while in Parts 3 and 4 inconsistent judgements were more frequently found, first one glass and then the other being judged to have more sugar.

4. Those situations which encouraged alternate focusing on the two aspects of the situation could lead to the achievement of conservation, while in those situations where alternate focusing tended to be delayed by strong perceptual illusions, for example in the case of area, conservation would take longer to achieve. This would explain the achievement of conservation in some situations and not in other situations, and would

be an alternative to Zimiles' explanation of Wohlwill and Lowe's findings. It would also explain Smedslund's finding that 'cognitive conflict' induced conservation, since in this case the cognitive conflict was in fact forcing the child to focus on two aspects simultaneously.

5. Piaget's application of game theory, which is paralleled by Zimiles' notion that number tends to be used more frequently as a method of estimating quantity because it gives the most consistent and predictable results, could account for the increasing tendency to give conservation judgements based on simultaneous focusings.

6. Eventually, and as a result of frequent simultaneous focusings, the child would reach a stage when simultaneous focusing was automatically applied to all situations. This would correspond to the stage of conservation.

Simultaneous focusing may not in itself result in conservation, but may be a necessary preliminary to building up the neural structures on which conservation is based. These structures would follow the same development as that described by Piaget for reversible systems of transformations.

a) As a result of frequent alternate or simultaneous focusings, the child attempts to relate the two aspects of the situation, and comes gradually to build up a system of inverse relationships between them.

b) Recognition of inverse relationships leads the child to consider the process of transformation from one state to the other. This would first be based on a system which recognises only one or two intermediate steps, but gradually an infinite series of continuous steps from one state to the other would be recognised, and finally a complete system of reversible transformations constructed.

This model offers an alternative explanation for the problems which Zimiles attempted to account for, and could provide a basis for the formulation of hypotheses which could then be subjected to experimental investigation.

CHAPTER X

GENERAL IMPLICATIONS OF STUDY AND SUGGESTIONS FOR FUTURE RESEARCH

In this chapter the general implications of our findings will be considered, and those problems which require further investigation will be pointed out. This will be preceded by some general comments on linguistic and methodological problems in cross-cultural studies.

This chapter is divided into the following sections:

1. General Questions of Language and Method.
2. Implications for Piaget's General Theory.
3. Implications for Levy-Bruhl's theory of Primitive Thinking.
4. Implications for Aboriginal Intelligence.
5. Implications for Education.

1. General Questions of Language and Method

In testing children from a different cultural and linguistic background the question of language and methodological difficulties inevitably arises.

Language

It could be argued that the poor performances of many of the children could be due to linguistic difficulties.

While we acknowledge that differences in language could influence the development of the concepts studied, we reject the view that linguistic difficulties could have masked the presence of concepts that had actually been achieved. That is, that the children had in fact achieved the concepts, but because they failed to understand the problem, or misunderstood the particular terms used, they did not show these concepts when questioned in English, but might have done so if questioned in their own language.

On all the tests the preliminary questioning determined whether or not the children were able to understand the essential terms used in the problem. No child was tested until it was clear that he understood the basic problem.

In those cases where the child did fail to understand the problem, which occurred only in the test on area and possibly in a few cases in volume, it seemed to be quite clear that the difficulty was a conceptual and not a linguistic difficulty. For example, on area, some children failed to understand that a house placed on the field of green grass reduced the amount of grass available on that field for the cow to eat. This was a conceptual difficulty.

On many of the problems, particularly when the children were asked for explanations, it was found that if they could not express their meaning in words, they did so in gestures. This was particularly clear on the test on length. If the children did not have a word to express 'curved' or 'zig-zag' they said: 'It goes like this', and with their finger they followed the form of the stick. While their limited means of expression may have prevented many of them from giving clear and explicit explanations for their judgements, it seems clear that the judgements themselves were not affected by linguistic difficulties.

This view is supported by Price Williams (1961), who reported that where a linguistic term was available to describe a classification, few of the children used this term, but instead gave a description of the classification. He also noted that linguistic terms were invented when they were not available in the language. For example, in perceptual experiments he found that a term for triangle (literally '3-cornered square', the term for square being that used for a square-shaped hut) was introduced by the people when it was required. These findings support the view that the formation of concepts is independent of their linguistic labels, and suggests that general terms may not be learned or used by children until a later age.

The argument has sometimes been put forward that failure on Piaget's tests may be due to a failure to understand the terms used, or to a different understanding of the terms. Success on Piaget's tests would then indicate no more than changes in vocabulary or in the meanings attached to words. This question has been discussed by Flavell ([1963] p.434-7). In the present context it could be argued that Aboriginal children are simply using our terms in a different way, and that apparent non-conservation answers are not due to a failure to understand conservation, but to a difference in the use of terms.

Like Flavell, we believe that this argument evades the central issue of the problem, which is the question as to <u>why</u> these terms are used in a different way. In particular, we may ask why some children use these terms in one way, and other children use the terms in another way, or why some children start by using the terms in one way, and then in the course of the test, or after experience on several tests, suddenly change their use of the term and consistently attach a different meaning to it. There is also a consistency in the child's behaviour when different terms are involved. The same child who judges that one glass has more sugar when the level is higher, also judges that one stick is longer when it is pushed forward, or that one cow has more grass to eat when the houses on his field are all in a row, or that the water level will rise higher when the ball is put into the glass than when the pieces of plasticine are put in. This suggests some underlying difficulty which is independent of the particular term used.

We therefore maintain that the poorer performance of the Aboriginal children was not due to a simple misunderstanding of the terms used, but was due to a conceptual difficulty and indicated the pre-operational stage of conceptual development described by Piaget.

Methodology

The question is sometimes raised as to whether studies based on Western European concepts and techniques are valid methods of evaluating intelligence or intellectual development in other cultural groups. It is sometimes suggested, for example, that if intelligence tests were constructed by Aborigines they might reveal that Aboriginals were more intelligent than Europeans. This argument seems to be based on a confusion of terminology. We have defined 'intelligence' in a certain way, and it is legitimate to determine to what extent this particular function or capacity is developed in other groups. It is no doubt true that Aborigines are very well adapted to their environment, and that they show great skill in hunting and highly developed musical and dancing abilities. But these abilities are not what we have defined as intelligence.

Piaget has distinguished between practical and logical thinking. Practical thinking, like sensori-motor intelligence, is concerned only with achieving an immediate aim, and not with reflection, classification, or explanation (see discussion p.12-3). Piaget maintains that practical intelligence is merely a continuation, on the representational plane, of the practical co-ordinations of sensori-motor intelligence. Many of the skills of the Aborigines, such as those of hunting, are based on such practical intelligence, and not on what Piaget terms operational thinking.

The suggestion that intelligence tests for Aborigines should be devised by Aborigines themselves, or should be based on what they themselves regard as intelligent behaviour, has perhaps best been answered by Porteus (1937), who states:

> To the inexperienced in anthropological work it might seem an easy matter to devise tests that will fit into the familiar cultural background of such people. It is not difficult to devise tests of this kind, but to have them mean much in relation to intelligence is a different matter (Porteus [1937] p.293).

Tests which are entirely dependent on a particular cultural background would clearly be unsuitable for cross-cultural study. But this does not mean that all of our techniques are unsuitable for application to other cultures.

Cowley (Cowley and Murray [1962]) has argued that the description and measurement of differences between groups, which can be carried out only with the use of techniques that have been developed in our society, is not only a legitimate study, but is necessary to the understanding of the development of these groups, and for formulating the causal relationships which, when tested, might indicate how this development could be modified.

Piaget maintains that intellectual development is dependent on the basic biological structures and functions of the organism, and results from the interaction between the individual and his physical environment. The concept of conservation is believed to be fundamental to all logical thinking and to develop as a result of the child's interaction with his physical environment, and not as a result of specific teaching. While one environment might provide more appropriate experiences than another for this development, conservation itself marks a particular level in a developmental process which is the same for all cultures. It is not therefore the product of a particular culture, and unrelated to development in other areas or concepts, but is fundamental to intellectual development in all cultures.

According to this view, the level of intellectual development of a particular culture could be determined by a study of the concept of conservation in that culture. This is precisely the purpose of the present study.

2. Implications for Piaget's General Theory

The finding that precisely the same stages of development and the same processes of thinking were found in Aboriginal children as in European children offers strong support to Piaget's view that these stages are determined by biological structures and functions that are common to all societies. The finding that these stages occur much later in Aboriginal children than in European children, and that in some cases the higher levels do not appear, is consistent with Piaget's view that development may be influenced by the physical and social environment, and is in agreement with his own prediction (Piaget in Tanner and Inhelder [1960] p.5).

The high co-efficients of reproducibility obtained, and the high homogeneity scores, indicate that the concepts studied followed a consistent order of development. This order of development was not the same as that postulated by Piaget and Inhelder in the case of quantity and weight, but the later development of conservation of volume was confirmed.

It has been suggested that variations from the expected order of development may have been due to the effects of experience on the previous tests, and to development which occurred during the testing period.

Our finding that the concepts followed a consistent order of development gives support to the view that Piaget's techniques may be used to construct a natural ordinal scale of development. However, other findings conflicting with this view have been reported. In most of these cases the tests have been presented in a random order, and it is possible that the effects of experience on the previous tests may be masking a consistent developmental order. A systematic study of order effects would be necessary to clarify this question.

A proposal for such a study has been set out in Appendix 7. Since our findings have suggested that the effects of experience may vary according to the age, stage of development, and intelligence of the individual, the proposed study would first investigate the effects of these factors on performance over a series of tests using a factorial design. Following this, samples could be selected according to age, stage of development, and intelligence, and a study of order effects undertaken by a factorial design in which each test is presented in each possible rank order to separate groups of children. If only three tests are used, for example, quantity, weight and volume, a study of rank order and sequence effects could be undertaken, the tests being administered in each possible sequence. If more than three tests are used, a study of sequence effects would be impractical, and rank order effects only could be studied.

Since the effects of experience may be greater among unschooled children and children from different cultural and environmental backgrounds, a separate study of order effects would need to be undertaken for such groups. Such a study could also investigate the question of whether or not there are critical periods for development. This could be established by determining whether or not order effects occur only within a certain age range, and not before or beyond this age range. If it is found that improvement with experience is much slower beyond a certain age, this would suggest that there may be critical periods during which appropriate experience leads to rapid development, and after which experience has much less effect and development is slower. This question would be related to Hebb's distinction between early and later learning, and would have important practical and theoretical implications.

Our findings therefore confirm Piaget's general theory of intellectual development, but further research would be required to determine whether or not conceptual development follows a natural ordinal scale.

3. Implications for Levy-Bruhl's Theory of Primitive Thinking

In Chapter I we drew a parallel between the theories of Piaget and Levy-Bruhl, and particularly between the pre-logical thinking described by Levy-Bruhl and the pre-operational thinking described by Piaget. We noted that Piaget had redefined Levy-Bruhl's notion of participation in terms of the distinction between reasoning based on hierarchical nestings of classes and going from the general to the particular or from the particular to the general, as found in logical thought; and reasoning which can only go from the particular to the particular because inclusive general classes have not been fully constructed, as found in the transductive reasoning of children and primitive reasoning based on Levy-Bruhl's law of participation. We therefore concluded that Piaget's techniques for investigating logical thought in children could be used to examine Levy-Bruhl's theory of primitive thinking.

Our finding that pre-operational thinking is still found in a number of Aboriginal children up to the age of 15 years offers strong support to Levy-Bruhl's view that pre-logical thinking may be characteristic of certain societies. The fact that these children had been attending school for up to eight years suggests that this mode of thinking may be characteristic of the many adult Aborigines who have not attended school at all.

Price Williams (1961) has rejected Levy-Bruhl's theory on the basis of his results on the development of concepts of number and quantity in West African children. However, Price Williams' results are not supported by those of other workers. Greenfield has found conservation of quantity much later in West

African children than in European children (see p.123). In preliminary work Prince[1] has found that conservation appears to be achieved some four to six years later in New Guinea children than in European. Our own results on the development of spatial concepts in African children (Cowley and Murray [1962]), and Kidd and Rivoire's (1965) analysis of cross-cultural studies based on the representation of spatial concepts, offer further support for the view that pre-operational thinking may persist in some cultural groups. This is also supported by our finding that few unschooled children up to 15 or 16 years showed conservation, and that non-conservation of quantity was found in the majority of the adult Aborigines tested (see Appendix 4).

The extent to which pre-operational thinking predominates in Aboriginal society is perhaps illustrated by the reaction of the interpreter at Elcho, an Aboriginal teaching assistant, when the test on conservation of quantity was first demonstrated to her. She immediately remarked that the children would think that the long glass had more sugar. This is in direct contrast to the reaction of the European adult, who will frequently refuse to believe that the children really think that the quantity can change. This reaction therefore suggests that the Aboriginal adult is much closer to pre-operational thinking than the European.

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[1] Personal communication.

A more extensive study of operational thinking among adult Aborigines is required before any clear conclusions can be drawn. The choice procedure adopted in testing the adults at Willowra suggests one suitable technique that could be used. Piaget (in Tanner and Inhelder [1960]) has suggested that his experiment on the seriation of sticks would be particularly suitable for cross-cultural study. Some of Donaldson's (1963) logical reasoning problems could also be adapted to determine whether formal thought can be achieved. A preliminary trial was carried out on some of the older Hermannsburg children using a modification of Donaldson's matching problem A2 (ibid., p.71). The results indicated that this kind of problem could be satisfactorily applied to these children. It would also seem possible to use the Aboriginal kinship system as a basis for drawing up problems to test their logical reasoning ability.

4. Implications for Aboriginal Intelligence

Our finding that the concept of conservation is developed much later in Aboriginal children than in European children, and in some cases does not appear to develop at all, seems to be conclusive evidence that intellectual development proceeds much more slowly in the Aboriginal culture, and that in general Aboriginals would achieve a much lower level of intellectual functioning than is normally achieved in the European culture.

The question as to what extent this difference in the rate of development and the final level of mental functioning achieved is due to differences in the social and physical environment, and to what extent it is due to differences in intellectual potential, must remain unanswered. In terms of Piaget's theory we would expect that the physical and social environment could contribute very markedly to these differences. Hunt (1961) has argued that the evidence on the effects of early experience indicate that the environment may have a very profound influence on development. This suggests that environmental differences may account for the later development of conservation in Aboriginal children.

Whether these differences may also be due in part to differences in intellectual potential cannot be established. Our finding that there were significant differences in performance between the part-blood and the full-blood children tested at Hermannsburg suggests that such differences may exist, and may have contributed to the later development of conservation in both the full-blood and the part-blood children. However the sample of part-blood and full-blood children tested was too small for these findings to be conclusive, and there was the further complicating factor that many of the children were interrelated, so that the differences found may have been due to family differences in intelligence. Since a large enough group where part-blood and full-blood children have been brought up in exactly the same conditions is unlikely to be found anywhere else in Australia, there is little possibility of checking these results in a further study.

The question as to whether or not there are racial differences in intellectual potential between Aborigines and Europeans would seem to be relatively unimportant. There are differences in intellectual potential between individuals, and it is likely that there are also differences between races, as argued by Morant (1956). However, it is unlikely that such differences would be absolute, and considerable overlap in intellectual potential between the two groups would be expected to occur. For this reason possible differences in average potential would be of little practical relevance. The problem is not to discover differences in intellectual potential, but to determine how best to develop the intellectual potential that is there.

However, the finding that the actual level of mental functioning achieved by Aboriginals under their present conditions is very much lower than that achieved by the average European would seem to have very important implications. Hebb (1949) has maintained that the effects of early experience can be permanent and lasting, and that early deprivation can severely limit later learning and the final level of development achieved. Evidence of the effects of early deprivation on later problem solving ability supports Hebb's theory, and the findings of Thompson and Heron (1954), cited by Hunt, offer support to the view that the effects of experience will be more marked the higher the phylogenetic level.

No evidence is available as to the extent to which early deprivation may limit the final level of mental functioning achieved, or the extent to which appropriate later experience can overcome the effects of early deprivation. This question is extremely important to the problem of Aboriginal intelligence.

Research in this area is urgently required. We have suggested that an investigation of order effects at different ages may yield information as to whether or not there is a critical period during which appropriate experience will lead to optimal development. Such a study would be relevant to this problem. It is also necessary to determine to what extent development can be induced by appropriate experiences, and what kinds of experience lead to most rapid development. Such research is required on adults as well as children. We have suggested methods of investigating operational thinking in adults, and such methods could also be used to study the effects of different kinds of experience in inducing conceptual development.

The assumption that there is no difference in intellectual ability between Aborigines and Europeans is commonly accepted. This assumption is based on the arguments that are used to support the view that there are no racial differences in intellectual potential. However, these arguments are irrelevant to the question of the actual differences that do occur in the level of mental functioning achieved. Apparently it is assumed that if there are no differences in potential ability, there will be no differences in actual ability, or that such differences that do occur can be very easily overcome by training. But the evidence of the permanent and lasting effects of early experience on later development indicate that this assumption is unfounded. Our findings suggest that many Aboriginals have not achieved operational or logical thinking. Whether or not this type of thinking can be achieved with appropriate experience at the adult level remains to be established. This problem has important practical implications for the education and training of adult Aborigines.

5. Implications for Education

While not directly concerned with this question, this study inevitably has important implications for the education of Aboriginal children. We have found that the majority of children up to 12 years, and many of those even up to 15 years, have still not achieved conservation, which, according to Piaget, is the basis for all operational thinking. Much of the school teaching is based on the assumption that this level of thinking has been reached, and that the children are capable of understanding concepts such as those of number and measurement. Our findings indicate that this assumption is false, and the low educational achievement of Aboriginal children may be due to the essential gap which must be bridged before the children are able to understand the concepts they are taught and to benefit from schooling.

In our discussion we have described this gap in terms of Hunt's (1961) 'match hypothesis'. The concepts which the children are being taught are too far beyond, or discrepant from, the concepts they are familiar with to enable them to assimilate them and accommodate to them. Hunt points out that discrepancies which are too large may lead to distress and negative motivation. This suggests that the teaching programme may be not only inadequate, but may be actually harmful to the children.

Goodnow (1962) has found that Chinese schoolboys not attending school tend to perform better on the conservation tests than those attending school. She suggests that the poorer performance of the school children may be due to poorly understood scientific teaching, and points out that at these schools science teaching was based on difficult text books and rote learning methods, and did not make use of practical demonstrations as in the European schools. This indicates the possible dangers of attempting to teach Western European scientific concepts to children from other cultural backgrounds by inadequate teaching methods. Goodnow's finding that the children not attending school performed better on the conservation tests also suggests that intellectual development may depend more on a rich and stimulating environment than on formal schooling. It is possible that formal schooling based on the rote learning of concepts which the children have difficulty in understanding, and without any direct activity with concrete materials, may tend to inhibit rather than to promote development.

The importance of activity with concrete materials is being increasingly recognised in education, and has given rise to new teaching methods such as the

Cuissenaire method. Dienes (1960, 1963, 1964) is developing new methods of teaching mathematics based on a wide variety of concrete materials, and he maintains that a variety of activity materials is essential for optimum learning.

The Cuissenaire method is being adopted in Aboriginal schools, and our findings suggest that it is having some influence on conceptual development. However, this influence seems to be fairly limited. While the effects of this method may take some years to become apparent, these findings do suggest that it is not in itself sufficient to promote the development of operational thinking. Dienes' view that a wide variety of activity materials is necessary may be relevant to this finding. It is possible that the success of the Cuissenaire method in European schools is dependent on the wide variety of experiences and materials the children have encountered in their everyday environment, and that the Cuissenaire teaching merely provides a framework for organising these experiences and crystallising out the essential features of the number concept. If this variety of experiences is lacking, the Cuissenaire method may be quite ineffective. In this case Dienes' method, which provides a wider range of activity materials, may be more suitable for Aboriginal children.

This view would be supported by Hebb's theory of the importance of early experience in laying the foundation for later learning, and is consistent with Piaget's theory that intellectual development proceeds by a gradual process of assimilation and accommodation based on the child's many experiences in interaction with his environment.

More research into this problem is clearly required. The effects of Cuissenaire teaching on conceptual development needs to be more carefully investigated, and the effects of other methods of teaching such as that of Dienes should be studied. In particular, it is necessary to determine what experiences will lead to most rapid development. Piaget's testing techniques could be used not only as a method of assessing the level of intellectual development reached, but may also provide or suggest the kind of experiences that would lead to development.

CONCLUSION

The main findings of the study can be summarised as follows:

1. The concept of conservation was found to develop later in Aboriginal children than in European children.
2. The same stages of development were found in Aboriginal children as in European children, with non-conservation being found in the younger children and conservation in the older children.
3. The concepts studied were found to be scalable by Guttman's criteria, and to yield high co-efficients of homogeneity.
4. The explanations and judgements given by the Aboriginal children revealed the same processes of reasoning and the same justifications for correct and incorrect judgements as have been reported by Piaget, and are consistent with Piaget's theory of development.
5. Significant differences were found between the performances of the full-blood and the part-blood children tested at Hermannsburg.

The differences that were found between the performances of the Aboriginal children and those reported by Piaget, and between the Elcho and Hermannsburg groups, have been idscussed in relation to environmental differences in the European and Aboriginal cultures and the particular environmental circumstances of the two groups, and also in relation to the question of order effects.

The implications of our findings for Piaget's theory of development, for theories of primitive thinking, and for the intelligence of Aborigines have been considered, and attention has been drawn to those problems which merit further investigation. We have emphasised the importance of cross-cultural studies as a means of investigating the causal factors which are operative in intellectual development, and the extent to which the environment may influence this development.

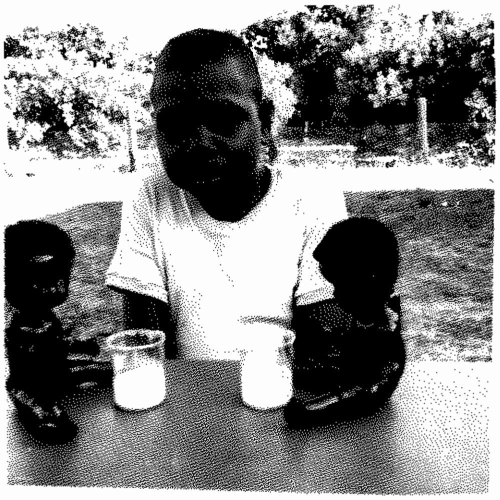
APPENDIX 1

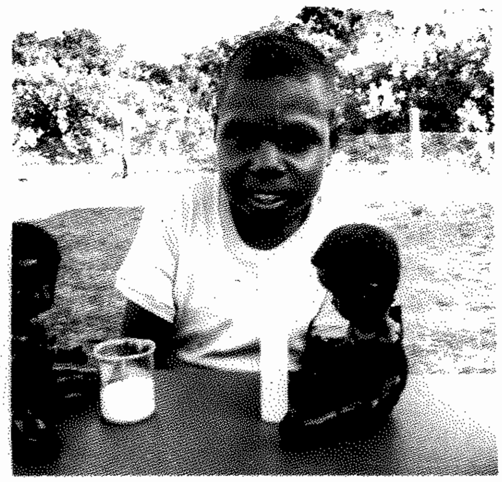
ILLUSTRATION OF TESTS

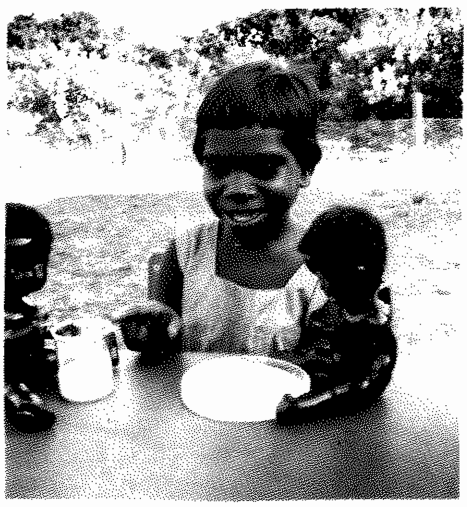
APPENDIX 1.

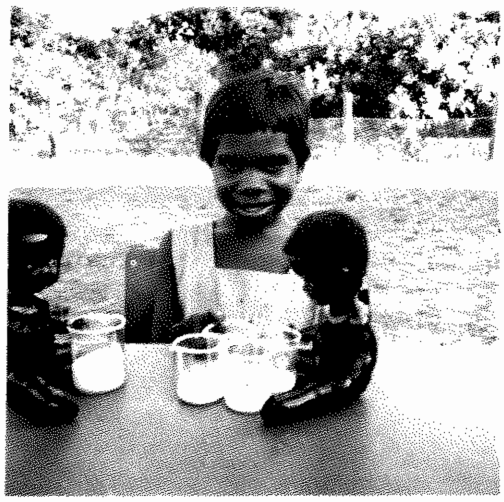
ILLUSTRATION OF TESTS.

1. QUANTITY









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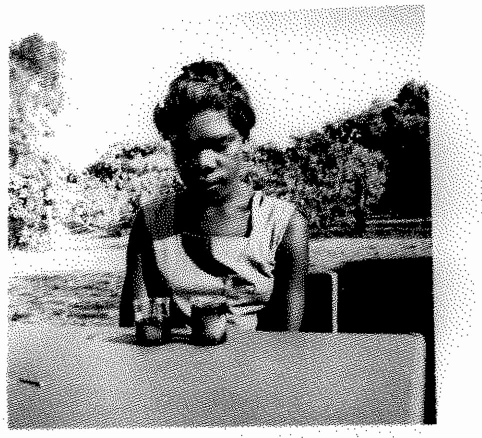
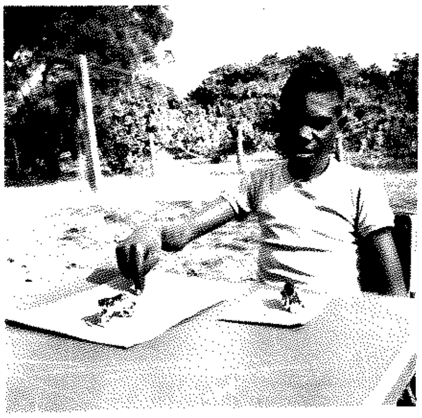
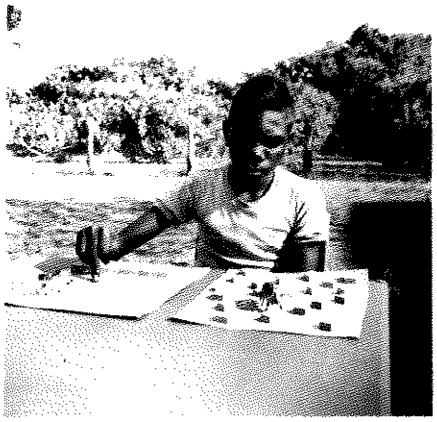
3. VOLUME



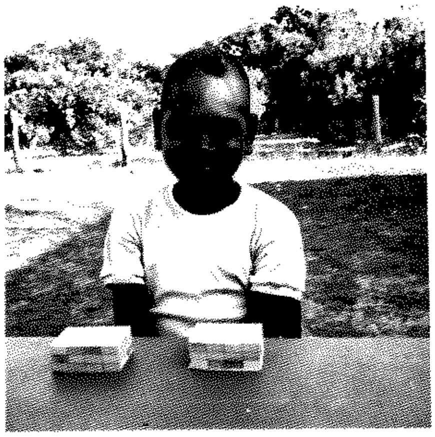
4. LENGTH

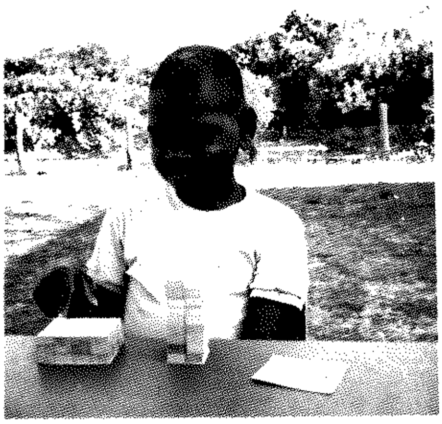
5. AREA





6. NUMBER





APPENDIX 2

PARTICULARS OF CHILDREN TESTED

APPENDIX 2

PARTICULARS OF CHILDREN TESTED

TABLE 1

Elcho Group

Particulars of Children Tested

Age Group	Age Range (yrs & mths)	Average Age (yrs & mths)	Grades								Male	Female	Ability			No.
			1	2	3C/D	3B	3A	3SA	4SA	6SA			AA	A	BA	
8	7;7 - 8;4	8;0	2*	10							5	7	4	5	3	12
9	8;6 - 9;5	8;10			10						7	3	4	4	2	10
10	9;6 - 10;4	10;1			7	1	2				5	5	-	6	4	10
11	10;6 - 11;5	11;0			4	3	1		2		5	5	4	3	3	10
12	11;8 - 12;6	12;2			1	-	2	4	3		3	7	2	5	3	10
13	12;9 - 13;3	13;0			1	-	3	2	2		5	3	2	4	2	8
14	13;8 - 14;4	13;11			-	-	2	2	-	1	4	1	1	4	-	5
Totals			2	10	23	4	10	8	7	1	34	31	17	31	17	65

* Both repeating Grade 1.

TABLE 2

Elcho Group

Number of Years Schooling

Age Group	No.	Number of Years*						Average No. of Years
		3	4	5	6	7	8	
8	12	11	1					3.1
9	10		10					4
10	10		2	8	1			4.2
11	10		1	8	1			5
12	10			4		2	3	6.4
13	8			6			2	6
14	5			3			2	6
Totals		11	14	29	2	2	7	

* Part year in which tested counted as full year.

TABLE 3

Elcho Group

Number of Years Experience with Cuissenaire

Age Group	No.	Period with Cuissenaire in Years				
		3½	2½	2	½	Total
8	12	1	11			12
9	10	10				10
10	10	2		5	2	9
11	10	3		1	1	5
12	10			1	2	3
13	8			1	3	4
14	5				2	2
Totals	65	16	11	8	10	45

TABLE 4

Hermannsburg Group

Particulars of Children Tested

Age Group	Age Range (yrs & mths)	Average Age (yrs & mths)	Grades				Male	Female	Full-Blood	Part-Blood	Ability			Total No.
			2	3	4	5					AA	A	BA	
8	7;8 - 8;5	8;1	10	2	-		7	5	8	4	3	5	4	12
9	8;7 - 9;6	8;11	4	5	-		6	3	5	4	4	3	2	9
10	9;9 - 10;5	10;1	1	9	1		6	5	5	6	4	6	1	11
11	10;8 - 11;2	11;0		5	4	1	2	8	7	3	7	2	1	10
12	11;6 - 12;5	12;0			5	4	4	5	3	6	4	4	1	9
13	12;8 - 13;6	13;1			2	8	6	4	6	4	3	4	3	10
14	13;8 - 14;5	13;11			2	5	2	5	4	3	1	5	1	7
15	14;7 - 15;5	14;11			1	11	4	8	4	8	4	6	2	12
Totals			16	23	19	30	37	43	42	38	30	35	15	80

TABLE 5

Hermannsburg Group

Number of Years Schooling

Age Group	No.	Number of Years*									Average
		2	3	4	5	6	7	8	9	10	No. of Years
8	12	1	4	7							3.5
9	9			8	1						4.1
10	11			1	10						4.9
11	10			1	4	5					5.1
12	9					5	4				6.4
13	10					1	6	3			7.2
14	7							4	3		8.4
15	12							1	6	5	9.3
Totals		1	4	17	15	11	10	8	9	5	

* Part year in which tested counted as full year.

TABLE 6

Hermannsburg Group

Number of Years Experience with Cuissenaire

Age Group	No.	Experience with Cuissenaire
		1 Year
8	12	12
9	9	9
10	11	10
11	10	5

TABLE 7

Hermannsburg Group

Classification of Part-Blood Children*

	Classification					Total
	11/16	3/4	13/16	7/8	15/16	
No.	1	8	4	22	3	38

* Proportion of Aboriginal ancestry, as given by the mission records.

TABLE 8

Average Ages of Elcho and Hermannsburg Groups

Age Group	Average Age	
	Elcho	Hermannsburg
8	8;0	8;1
9	8;10	8;11
10	10;1	10;1
11	11;0	11;0
12	12;2	12;0
13	13;0	13;1
14	13;11	13;11
15	-	14;11

TABLE 9

Average Number of Years Schooling
Elcho and Hermannsburg Groups

Age Group	Average Number of Years Schooling	
	Elcho	Hermannsburg
8	3.1	3.5
9	4	4.1
10	4.2	4.9
11	5	5.1
12	6.4	6.4
13	6	7.2
14	6	8.4
15	-	9.3

APPENDIX 3

PILOT STUDY AND PRELIMINARY TESTING

I. The Pilot Study

The pilot study was carried out at Hermannsburg in October 1963. Some testing for this study was also carried out at the school in Bagot, the Aboriginal settlement in Darwin.

A brief statement of the tests used in this study and the conclusions drawn is given.

1. General Findings

1) It was not satisfactory to use an interpreter in testing the children for the following reasons:

a) The children tended to become very shy in the presence of an interpreter, and often refused to respond or to answer questions. In the presence of the experimenter only it was much easier to get the child to feel at ease and to respond freely to the questions and situations.

b) The only interpreters available were Aboriginals on the mission stations, who had had a very limited education and who were unable to understand or appreciate what was required in the test situation. It was therefore very difficult to get them to translate the questions precisely as was required, and not to add anything further on their own account; or to get them to translate as literally as possible the children's replies. Very often they showed annoyance and tried to correct the child when he gave an answer they thought was incorrect. Sometimes they would not translate the child's replies, saying only that the child 'didn't say anything'. No amount of explanation, instruction, persuasion or correction was sufficient to ensure that the interpreter carried out the task as required, and repeated cautionings and corrections resulted in resentment on the part of the interpreter and a strained relationship between the experimenter and interpreter. This was obviously not desirable in the testing situation.

2. Children from five to about seven years could not be tested without an interpreter. Children of this age often either did not answer the questions, or gave contradictory or random answers. These responses appeared to be similar to those referred to by Piaget as characteristic of children of about three to four years, who were too young to understand the problems and could not be tested.

From about eight years the children could understand the problems and answer the questions in English, and could therefore be tested without an interpreter. (The medium of instruction in the schools was English, and the children started school at about six years.) A good relationship could be established with most of the children, particularly after they had done one or two tests and had become familiar with the situation and the experimenter. In a few cases it was difficult to get the children to answer the questions or to give explanations for their answers.

3. In cases where the child was actually required to do something, for example to pick out the same number of sweets as that in a given row or configuration, many of the children, particularly the younger children, failed to respond at all, or else took so long to respond that it delayed the testing procedure considerably. It was therefore found much quicker and more satisfactory to present the child with a given situation and to question him on this, rather than to ask him to construct the situation himself.

2. Findings on Each Test, and Reasons for Rejection of Modification of the Tests

1. Number

Three tests on number were presented, based on those described by Piaget (1952). These were:

1. Spontaneous correspondence.
2. Composition of number.
3. Composition of classes.

These tests were applied to 24 children from 5 to 9 years.

The majority of children at five and six years were classified at Piaget's Stage I. In the tests on spontaneous correspondence and composition of classes the majority of children from seven years were classified at Stage III, but in the test on composition of number only two children reached this stage, and most of the children were classified at Stage II.

These tests proved to be on the whole unsatisfactory. It was difficult to pose the questions in such a way as to get unambiguous results, and a number of the children failed to understand the problems. The younger children seemed to be answering at random, while the responses of the older children seemed to be influenced by their school learning on number, and lacked certainty and conviction. While most of the older children showed conservation of number in the one-one correspondence situation, they performed very poorly on the test on composition of number. Most of the tests required some activity on the part of the subject; for example, picking out an equal number of objects, or dividing one pile into two equal piles. Many of the children failed to respond when asked to do this, or else took so long that it made the testing periods very long and tedious.

These tests were therefore excluded from the main study. Some seven and eight year old children at Elcho were tested on a modified form of the tests on spontaneous correspondence and composition of classes, but the tests were still not satisfactory and these results have not been reported.

2. Conservation of Length and Distance

The tests on conservation of length and distance described by Piaget, Inhelder and Szeminska (1960) were applied to 28 children at Hermannsburg and 11 children at Bagot. The children were aged from 5 to 13 years.

A. Distance

It was found that the majority of children from about nine years were able to conserve distance. However, this test was not very satisfactory, since the children had difficulty in understanding the problem and became confused, and their answers often appeared to be random. This test was therefore excluded from the main study.

B. Length

About half the children from five to eight years and the majority of the children over nine years were able to solve the first problem on length (Part I in the main study). Conservation of length was generally found only from about nine to ten years.

This test was found to be very satisfactory. The children had no difficulty in understanding the problem and the results were quite clear cut. This test was therefore included in the main study, and a standard procedure and score sheets were drawn up on the basis of these results.

3. Conservation of Quantity, Weight and Volume

Piaget and Inhelder's (1962) test on the conservation of the quantity, weight and volume of a transformed plasticine ball was applied to 14 children from 7 to 14 years.

Non-conservation was found in most of the children up to about 11 years, and transitional or conservation responses were generally found from 12 years.

No invariant order was found in the development of conservation of quantity, weight and volume, and in fact more children succeeded on weight and volume than on quantity.

This test was not satisfactory for the following reasons:

1. The children seemed to have difficulty in understanding what was meant by 'the same amount' of plasticine, and seemed at times to be confusing 'same amount' with 'same shape'. That is, they seemed to be saying that it was <u>not</u> the same, meaning that it was not the same <u>shape</u>, when they were being asked if the <u>amount</u> of plasticine was the same. While such a confusion may well be associated with non-conservation, it is nevertheless important to avoid the possibility of a purely verbal misunderstanding. Similar problems were also found in the case of weight.

2. The problem posed appeared to be relatively meaningless to the children. It did not seem to be important to them to decide whether or not the quantity or weight of the plasticine was exactly the same, and many of them showed lack of interest and carelessness in their replies.

3. The fact that the questions on conservation of quantity, weight and volume followed one another immediately led to perseveration of the same type of answer from one test to the next, and in some cases an improvement from quantity to weight and from weight to

volume, apparently as a result of increased familiarity with the test situation.

In view of these problems the tests on conservation of quantity, weight and volume were modified for the main study. The aims of the modifications were as follows:

1. To make the problems more meaningful and interesting to the children.

2. To vary the situation for each problem and to make each test separate and independent.

It was hoped that this would reduce the effects of perseveration and the direct influence of experience from one test to the next.

The modifications introduced for each test were as follows:

A. Quantity

A new situation was chosen based on Piaget's (1952) test of continuous quantities. Sugar was chosen as the quantity to be compared, since this was a familiar and desirable foodstuff and the questions on comparison would therefore be more meaningful to the children, and could be supplemented with questions referring to the amount of sugar there was 'to eat'. (The practice in the Geneva study of asking the children to pretend that the plasticine was cake or some other edible was not found practicable with Aboriginal children.)

To make the problem more interesting for the children two black dolls were introduced, and the problem was introduced as a game in which the sugar was to be given to the dolls to eat.

B. Weight

Since a number of the children seemed to have some difficulty in understanding the concept of weight, a balance scale was introduced so that this concept could be explained and demonstrated to the children, and the initial equality of weight of the quantities to be compared could be established. Tea leaf was chosen as the quantity to be weighed and compared since this was very familiar to the children and formed an important part of the regular rations handed out to the people. Since foodstuffs were commonly carried in various types of bags it was hoped that the problem of transferring the tea leaf to bags of different shapes and sizes would be meaningful to the children.

C. Volume

Since the children seemed to understand the problem of volume based on the displacement of water by the plasticine balls quite well, this test was retained in the main study.

In the pilot study the child was asked to indicate with his finger where he thought the water would come to when the plasticine was placed inside the glass. Sometimes it was found that the level he indicated conflicted with his verbal judgement. However, this method was not very satisfactory, since the children's indications were often very imprecise, and some of the children simply pointed to the glasses or did not understand the question. Diagrammatic sketches were therefore devised to check the children's verbal judgements.

4. Formal Operational Tests

Two tests from Inhelder and Piaget's (1958) study of formal thinking were also applied in the pilot study. These were:

1. Equilibrium in the balance.
2. The law of floating bodies.

The balance test was applied to 22 children from 7 to 14 years, and the floating bodies test was presented to 5 children from 12 to 14 years. None of the children tested appeared to have reached the level of formal operational thinking.

The children showed considerable interest in working with the balance, and it is possible that this test could be modified to study formal thinking. Little interest was shown in the floating bodies test.

These tests were not satisfactory as they were presented, and were excluded from the study.

II. Preliminary Study

The preliminary testing was carried out at Milingimbi in June 1964.

Appendix 3

Following the pilot study, standardised procedures were drawn up for the main study for the tests on conservation of quantity, weight, volume and length. In addition, procedures were drawn up for two additional tests. These were:

1. Conservation of area (from Piaget, Inhelder and Szeminska [1960], Chapter 11, Section I).
2. Conservation of volume using unit blocks (from Piaget, Inhelder and Szeminska [1960], Chapter 14).

The procedures were based on those described by Piaget.

All the procedures were tried out and finalised in the preliminary testing at Milingimbi.

The results of the preliminary testing were as follows:

1. The procedures drawn up for the tests on quantity, weight, volume, length and area were all found to be satisfactory, and only a few minor modifications were introduced. In all the tests it was found necessary to start with the comparison of unequal quantities to make sure that the children understood the test and the terms used, and was answering consistently. This initial comparision was also used to determine whether the child understood the comparative term 'more', or whether he could only use the term 'lots'. If he was unable to use either of these terms, or an equivalent term, consistently, there was clearly no point in proceeding further with the test.

In the test on area the introduction using the unequal sized fields served to direct the child's attention to the amount of grass available as the criterion of which cow had more grass to eat. Without this introduction the children tended to make arbitrary judgements as to which cow would eat more, and did not base their judgement on the actual size of the field or the grass available.

2. The block test was not suitable for the study of conservation of volume. The children did not understand the term 'space', and it was not possible to get this idea across to them. However, it was found that in this situation the children showed non-conservation of the number of blocks at a much later age than in the one-one correspondence test. This test was therefore modified as a test of conservation of number, and was included in the study.

APPENDIX 4

SUPPLEMENTARY TESTING

Supplementary testing was carried out on unschooled children and adults at Elcho and Willowra. Some of the children at Elcho had had limited schooling (one to two years). In most cases an interpreter was used, but some of the Elcho children were tested without an interpreter. The difficulties of testing with an interpreter have been pointed out, and the results of this testing must be interpreted with caution.

Elcho Group (Children)

The children were tested on conservation of quantity and length. The results are shown in Table 1.

From these results it can be seen that very few unschooled children between the ages of 10 to 15 years have achieved conservation.

Willowra Group (Adults)

The tests on conservation of quantity and length were applied. The results are shown in Table 2. Only about one third of the adults showed conservation of quantity, while three quarters showed conservation of length. While these results must be considered very tentative owing to difficulties of translation and the possibility of misunderstanding, they suggest that conservation may be achieved in some areas but not in others. A number of the adults tested were working on the station, and would have been engaged in activities such as building and constructing fences. This may explain the greater success on conservation of length.

In view of the difficulties of the translation and interpretation of the tests, a second test was devised based on a simple choice situation. Sugar was poured into two glasses, the standard glass and the long thin glass, and the subjects were asked to choose which sugar they wanted. They kept the sugar they chose. The sugar was poured into the glasses from a measuring glass, and in each case the subject was asked to watch very carefully as the sugar was poured out, and the measuring glass was emphasised on each occasion by pointing and by gesture. In the first case, one measuring glass was poured into the long glass and the standard glass. Eleven out of twelve women chose the sugar in the long glass. In the second case, one measuring glass was poured into the long glass, and one and a half measuring glasses were poured into the standard glass. Eight out of twelve women chose the sugar in the long glass; that is, they chose the glass with <u>less</u> sugar. These results would seem to confirm the dependence on the perceptual situation and the reality of non-conservation among adult Aborigines.

TABLE 1

ELCHO NON-SCHOOL GROUP (CHILDREN)

NUMBER OF CHILDREN CLASSIFIED AT EACH STAGE OF DEVELOPMENT

A. CONSERVATION OF QUANTITY

Age Groups	No.	Stages		
		I Non-conservation	II Transitional	III Conservation
10	3	3	-	
11	8	7	1	
12	6	4	1	1
13	13	6	4	3
14	4	2	2	
15+	3	1	2	
Totals	37	23	10	4

B. CONSERVATION OF LENGTH

Age Groups	No.	Stages		
		I Non-conservation	II Transitional	III Conservation
10	2	2		
11	8	6		2
12	6	6		-
13	13	8	3	2
14	4	2		2
15+	3	3		
Totals	36	27	3	6

TABLE 2

WILLOWRA ADULT GROUP

NUMBER OF SUBJECTS CLASSIFIED AT EACH STAGE OF DEVELOPMENT ON CONSERVATION OF QUANTITY AND CONSERVATION OF LENGTH

Tests	No.	Stages		
		I Non-conservation	II Transitional	III Conservation
Quantity	26	13	6	7
Length	24	3	3	18

APPENDIX 5

QUALITATIVE ANALYSES OF RESULTS

APPENDIX 5

QUALITATIVE ANALYSES OF RESULTS

TABLE 1

QUANTITY

INCONSISTENCIES BETWEEN CONSERVATION AND NON-CONSERVATION JUDGEMENTS

A

NUMBER OF CHILDREN SHOWING INCONSISTENCIES ON ONE, TWO OR ALL PARTS OF THE TEST[1]

Stage[2]	No.	Inconsistencies: Nil	In 1 Part	In 2 Parts	In all Parts
Elcho Group					
I	25	9	10	5	1
II	22	-	6	9	7
III	19	15	4	-	-
Hermannsburg Group					
I	41	10	5	18	8
II	18	-	-	7	11
III	25	9	10	5	1

1 Parts of the test refers here to the three separate problems presented to the child i.e.,
Part 2. Sugar in standard glass compared with sugar in long glass.
Part 3. Sugar in standard glass compared with sugar in wide glass.
Part 4. Sugar in standard glass compared with sugar in four small glasses.

2 Stage I = Non-conservation, Stage II = Transitional Stage III = Conservation.

TABLE 1 (Contd.)

B

NUMBER OF CHILDREN SHOWING INCONSISTENCIES ON PART 2, PART 3, AND PART 4 OF THE TEST

Stage	No.	Inconsistencies		
		Part 2 (long glass)	Part 3 (wide glass)	Part 4 (4 small glasses)
Elcho Group				
I	25	3	9	11
II	22	12	14	17
III	19	4	-	-
Total	66	19	23	28
Hermannsburg Group				
I	41	16	25	24
II	18	15	18	13
III	25	13	2	8
Total	84	44	45	45

TABLE 2

WEIGHT

INCONSISTENCIES BETWEEN CONSERVATION AND NON-CONSERVATION JUDGEMENTS

A

NUMBER OF CHILDREN SHOWING INCONSISTENCIES ON ONE, TWO OR ALL PARTS OF THE TEST

Elcho Group					
		Inconsistencies			
Stage	No.	Nil	In 1 Part	In 2 Parts	In all Parts
I	26	14	9	2	1
II	13	-	5	6	2
III	26	21	4	1	-
Hermannsburg Group					
I	27	15	10	2	-
II	10	-	-	5	5
III	45	27	11	6	1

TABLE 2 (Contd.)

B

NUMBER OF CHILDREN SHOWING INCONSISTENCIES ON PART 2, PART 3, AND PART 4 OF THE TEST

Stage	No.	Inconsistencies		
		Part 2 (large bag)	Part 3 (long bag)	Part 4 (6 small bags)
Elcho Group				
I	26	8	6	2
II	13	10	4	9
III	26	-	4	2
Total	65	18	14	13
Hermannsburg Group				
I	27	10	4	-
II	10	9	9	7
III	45	11	8	7
Total	82	30	21	14

TABLE 3

QUANTITY

PREFERENCES FOR WHICH GLASS IS JUDGED TO HAVE MORE SUGAR ON EACH PART OF THE TEST

(NUMBER OF CHILDREN SHOWING EACH PREFERENCE)

Groups and Stages	No.	Part 2 Preference			Part 3 Preference			Part 4 Preference		
Elcho		A	L	Eq	A	W	Eq	A	C's	Eq
I	25	-	25	-	17	8	-	15	8	2
II	22	-	22	-	11	6	2	10	9	1
III	4*	-	4	-	-	-	-	-	-	-
Hermannsburg										
I	41	-	41	-	17	24	-	23	13	5
II	18	-	17	-	9	6	2	13	4	1
III	16*	1	10	2	1	1	-	4	4	-
Total Preferences		1	119	2	55	45	4	65	38	9

* No. giving at least one non-conservation response.

A = Standard glass.

L = Long glass.

W = Wide glass.

C's = 4 small glasses.

Eq = Equal preference.

TABLE 4

WEIGHT

PREFERENCES FOR WHICH BAG IS JUDGED HEAVIER ON EACH PART OF TEST

(NUMBER OF CHILDREN SHOWING EACH PREFERENCE)

Groups and Stages	No.	Part 2 Preference				Part 3 Preference				Part 4 Preference			
Elcho		A	W	Eq	NoJ	A	L	Eq	NoJ	A	Bs	Eq	NoJ
I	26	6	15	3	2	3	20	1	2	18	3	4	1
II	13	4	2	-	7	-	11	-	2	8	3	-	2
III	5*	-	-	-	5	1	3	-	1	1	1	-	3
Hermannsburg													
I	27	8	10	5	4	6	16	3	2	24	2	1	-
II	10	3	1	-	6	2	5	-	3	6	3	1	-
III	18*	3	6	2	7	2	5	1	10	4	3	-	11
Total Preferences		24	34	10	31	14	60	5	20	61	15	6	17

* No. giving at least one non-conservation response.

A = Standard bag.

W = Wide bag.

Eq Equal preference.

NoJ = No non-conservation judgement.

TABLE 5

VOLUME

PREFERENCES FOR WHICH BALL JUDGED TO MAKE THE WATER RISE HIGHER

A. JUDGEMENTS

(NUMBER OF CHILDREN SHOWING EACH PREFERENCE)

Groups and Stages	No.	Part 2 (ball & flat) Preference				Part 3 (ball & long) Preference				Part 4 (ball & pieces) Preference			
		B	F	Eq	NoJ	B	L	Eq	NoJ	B	P	Eq	NoJ
Elcho													
I	42	22	13	1	6	27	7	1	7	10	17	3	12
II	6	1	1	-	4	4	-	-	2	-	1	-	5
III	17	-	-	-	17	1	-	-	16	1	-	-	16
Hermannsburg													
I	51	34	11	6	-	37	7	5	2	37	12	1	1
II	19	8	5	1	5	11	2	2	4	6	1	-	12
III	11	2	1	-	8	2	-	-	9	1	-	-	10

B = Ball.

F = Flat.

L = Long.

P = Pieces.

Eq = Equal preference.

NoJ = No non-conservation judgement.

TABLE 5 (Contd.)

B. DRAWINGS

(NUMBER OF CHILDREN DRAWING LEVEL HIGHER FOR EACH CASE)

Groups and Stages	No.	Part 2			Part 3			Part 4		
		Level higher for:		Level same	Level higher for:		Level same	Level higher for:		Level same
		B	F		B	L		B	P	
Elcho										
I	42	22	6	14	26	6	10	20	10	12
II	6	2	1	3	2	1	3	1	1	4
III	17	-	-	17	1	-	16	-	-	17
Hermannsburg										
I	51*	42	2	6	42	2	6	44	2	4
II	19	14	1	4	14	4	1	11	2	6
III	11	-	-	11	-	-	11	-	-	11

* 1 child unable to draw levels.

B = Ball.

F = Flat.

L = Long.

P = Pieces.

TABLE 6

QUANTITY

NON-CONSERVATION EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Non-conservation Explanations[1]								
		Type A		Type B		Others				
		i) Lots/More	ii) Full	i) Size	ii) Shape	1 H	2 C	3 I	4 D	5 O
Elcho										
I	25	7	-	1	5	-	1	2	-	-
II	22	7	2	2	5	-	-	-	1	-
III	4*	1	1	-	-	-	-	-	-	-
Hermannsburg										
I	41	21	23	25	20	-	1	1	1	4
II	18	7	3	9	11	-	2	1	2	3
III	16*	2	5	3	8	-	-	1	-	-

1 For description of explanations, see text pp.254-7.

* Number giving at least one non-conservation response.

H = Heavy.

C = Contradictory.

I = Irrelevant.

D = Different.

O = Other.

TABLE 7

WEIGHT

NON-CONSERVATION EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Non-conservation Explanations[1]								
		Type A		Type B		Others				
		i) Lots/More	ii) Full	i) Size	ii) Shape	1 H	2 C	3 I	4 D	5 O
Elcho										
I	26	6	3	7	6	5	-	1	2	-
II	13	5	1	2	4	3	-	2	1	-
III	5*	2	-	-	-	2	-	-	-	-
Hermannsburg										
I	27	9	12	14	5	7	-	-	1	2
II	10	3	3	8	7	1	-	-	-	-
III	18*	4	7	7	6	1	-	2	-	2

1 For description of explanations, see text pp.254-7.

* Number giving at least one non-conservation response.

H = Heavy.

C = Contradictory.

I = Irrelevant.

D = Different.

O = Other.

TABLE 8

VOLUME

NON-CONSERVATION EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Non-conservation Explanations[1]								
		Type A		Type B		Others				
		i) Lots/More	ii) Full	i) Big	ii) Shape	1 H	2 C	3 I	4 D	5 O
Elcho										
I	42	6	1	19	16	-	4	3	3	-
II	6	-	-	2	2	-	-	-	-	-
III	17	-	-	-	3	-	-	-	-	-
Hermannsburg										
I	51	1	9	28	34	1	-	-	-	1
II	19	-	-	3	12	2	-	-	-	-
III	11	-	-	1	6	1	-	-	-	-

1 For description of explanations, see text pp.254-7.

H = Heavy.

C = Contradictory.

I = Irrelevant.

D = Different.

O = Other.

TABLE 9

QUANTITY

CONSERVATION EXPLANATIONS

A

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Conservation Explanations				
		1 Cor	2 R	3 I	4 Con	NoE
Elcho[1]						
II	22	2	7	4	4	9
III	19	13	6	3	-	-
Hermannsburg						
I	25	-	8	6	10	5
II	18	8	4	5	7	8
III	26	23	8	3	4	2

1 No conservation explanations given in Stage I.

Cor = Correct.

R = Repetitive.

I = Irrelevant.

Con = Contradictory.

NoE = No explanation.

TABLE 9 (Contd.)

B

CLASSIFICATION OF CORRECT EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF CORRECT EXPLANATION

Groups and Stages	No. giving at least one correct explanation	Correct Explanations[1]			
		Reversibility[2]		Identity[3]	
		1 Poured	2 Put back	3 Explicit	4 Implicit
Elcho					
II	2	-	1	-	1
III	13	2	1	8	5
Hermannsburg					
II	8	-	-	4	5
III	26	2	1	12	14

1 For description of explanations, see text pp.257-61.

2 Referring to Reversibility

1 e.g., 'You poured it'
2 e.g., 'If you put it back it would be the same'

3 Referring to Identity

3 Explicit e.g., 'It was the same before'
4 Implicit e.g., 'Both had same'

TABLE 10

WEIGHT

CONSERVATION EXPLANATIONS

A

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Conservation Explanations[1]				
		1 Cor	2 R	3 I	4 Con	NoE
Elcho						
I	14*	-	7	-	4	4
II	13	1	6	3	3	2
III	26	14	15	5	4	2
Hermannsburg						
I	19*	2	9	3	9	2
II	10	4	7	-	4	-
III	45	37	28	2	3	1

1 For description of explanations, see text p.257-61.

* Only those giving explanations for conservation judgements included.

Cor = Correct.

R = Repetitive.

I = Irrelevant.

Con = Contradictory.

NoE = No explanation.

TABLE 10 (Contd.)

B

CLASSIFICATION OF CORRECT EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF CORRECT EXPLANATION

Groups and Stages	No. giving correct explanation	Correct Explanations[1]			
		a) Poured	b) Before/ In A'	c) Balance	d) Same tea
Elcho					
II	1	-	1	-	-
III	14	1	6	4	5
Hermannsburg					
I	2	-	1	1	-
II	4	-	4	3	1
III	37	-	20	17	16

1

a) e.g., 'You just poured it from this bag to this bag.'

b) e.g., 'I saw it was the same before' or 'I saw it was the same in this bag (A').'

c) e.g., 'I saw it here' (on the balance) or 'It weighed same on here' (the balance).

d) e.g., 'It is the same tea.'

TABLE 11

VOLUME

CONSERVATION EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Explanations[1]							
		1. Correct			2 Repetitive		3 I	4 C	5 D
			Referring to identity						
		RR	E	I	S	SH			
Elcho									
I	42	-	-	3	14	-	5	11	4
II	6	-	3	3	3	-	1	-	-
III	17	2	12	2	11	-	2	-	3
Hermannsburg									No Ans.
I	51	-	-	4	7	-	2	12	12
II	19	-	6	11	3	-	1	1	3
III	11	-	7	5	3	2	-	-	2

1 For description, see text pp.257-61.

I = Irrelevant.

C = Contradictory.

D = Description.

RR = Referring to reversibility (transformation).

E = Explicit (e.g., 'same before').

I = Implicit (e.g., 'same ball').

S = Same.

SH = Same heavy.

TABLE 12

QUANTITY

SUPPLEMENTARY QUESTIONING

i) 'IF PUT BACK'

NUMBER OF CHILDREN JUDGING THAT THE QUANTITIES WOULD NOT BE THE SAME 'IF PUT BACK' ON AT LEAST ONE OCCASION

Stages	No. Questioned	Judging same all occasions	Judging not same at least one occasion
Elcho			
I	19	13	6
II	22	19	3
III	4	4	nil
Hermannsburg			
I	41	21	20
II	18	13	5
III	12	12	nil

TABLE 12 (Contd.)

B

NUMBER OF CHILDREN JUDGING QUANTITY TO BE THE SAME IMMEDIATELY AFTER 'PUT BACK' QUESTION ON AT LEAST ONE OCCASION

Stages	No. Questioned	Where previously judged same	Where *not* previously judged same
Elcho			
I	19	1	6
II	22	9	10
III	4	1	3
Hermannsburg			
I	41	5	14
II	18	7	5
III	12	7	3

TABLE 13

QUANTITY

SUPPLEMENTARY QUESTIONING

ii) 'SAME TO EAT'

NUMBER OF CHILDREN TENDING TO JUDGE THAT THE QUANTITY IS THE SAME TO EAT AFTER INITIAL NON-CONSERVATION JUDEMENT ON ONE, TWO AND THREE PARTS OF THE TEST

HERMANNSBURG GROUP

Stage	No. giving at least one N.C. judgement	Tendency to judge same to eat		
		1 Part	2 Parts	3 Parts
I	41	15	7	-
II	18	5	3	3
III	16	6	2	-

TABLE 14

WEIGHT

INCONSISTENCIES BETWEEN WEIGHT AND BALANCE JUDGEMENTS

A

NUMBER OF CHILDREN SHOWING PERSISTENT INCONSISTENCIES IN WEIGHT AND BALANCE JUDGEMENTS

Stages	No. Questioned	Inconsistencies in	
		1 Part	2 Parts
Elcho			
I	15	2	-
II	6	4	-
III	5	1	-
Hermannsburg			
I	27	11	5
II	10	6	1
III	18	3	1

TABLE 14 (Contd.)

B

ANALYSIS OF PERSISTENT INCONSISTENCIES

Groups and Stages	No. showing persistent inconsistencies	Category 1 NC for weight and balance			Category 2 C for balance NC for weight			Category 3 C for weight NC for balance		
		Parts of test			Parts of test			Parts of test		
		2 Lr/b	3 L/b	4 S/b	2 Lr/b	3 L/b	4 S/b	2 Lr/b	3 L/b	4 S/b
Elcho										
I	2					1				1
II	4				1		1			2
III	1					1				
Hermannsburg										
I	16	1		5	5	3	6	1		
II	7		2	2	1	1	1	1		
III	4	2	1		1		-	1		

NC = Non-conservation.

C = Conservation.

Lr/b = Large bag.

L/b = Long bag.

S/b = Small bag.

TABLE 14 (Contd.)

C

ANALYSIS OF CHANGES THAT OCCURRED TO RESOLVE INITIAL INCONSISTENCIES BETWEEN WEIGHT AND BALANCE JUDGEMENTS

Stages and Groups	No.*	No. of initial inconsistencies (Max in each case = N x 3)	Changes in judgement					
			NC changes		Change from NC to C		Change from C to NC	
			To agree with (W)	(B)	To agree with (W)	(B)	To agree with (W)	(B)
Elcho								
I	26	5	1	1	1	-	1	1
II	13	3	1	-	1	-	1	-
III	5	3	-	-	3	-	-	-
Hermannsburg								
I	27	6	4	2	-	-	-	-
II	10	11	1	-	1	6	2	1
III	18	15	-	-	2	10	2	1

* Not all Elcho subjects questioned on balance judgements.

NC = Non-conservation.

C = Conservation.

W = Weight.

B = Balance.

TABLE 15

WEIGHT

SUPPLEMENTARY QUESTIONING WHERE A COMPARED WITH SOME OF SMALL BAGS

ELCHO GROUP

A

CLASSIFICATION OF RESPONSES

Stages	No. Questioned	Classification 1 Correct	2 Correct after initial errors	3 Incorrect
I	11	-	-	11
II	7	-	1	6
III	26	19	7	-

TABLE 16

VOLUME

CONSISTENCY BETWEEN JUDGEMENTS AND DRAWING

A

COMPARISON BETWEEN DRAWING AND JUDGEMENTS

Groups and Stages			1 Where levels drawn equal (conservation for drawing)			2 Where levels drawn unequal (non-conservation for drawing)		
	No.	Total No. of cases (Nx3)	Judgements			Judgements		
			C	NC	I	C	NC	I
Elcho								
I	42	126	12	13	12	13	57	18
II	6	18	4	2	4	6	2	-
III	17	51	47	2	1	1	-	-
Hermannsburg								
I	51	153*	-	2	14	3	76	55
II	19	57	5	3	6	18	4	21
III	11	33	27	1	5	-	-	-

* In one case the child was unable to draw the levels.

C Conservation.

NC = Non-conservation.

I = Inconsistent.

TABLE 16 (Contd.)

B

NUMBER OF CASES SHOWING CONSISTENCIES AND INCONSISTENCIES BETWEEN JUDGEMENTS AND DRAWING

Groups	Drawing and judgement consistent			Drawing and judgement inconsistent			Where judgements inconsistent		
							Levels drawn		
	A C.	B NC.	Total	A C. for drawing	B C. for judgement	Total	A Equal (C)	B Unequal (NC)	Total
Elcho	63	59	122	16	20	36	17	18	35
Hermannsburg	32	80	112	6	21	27	25	76	101

C = Conservation.

NC = Non-conservation.

TABLE 17

LENGTH

NUMBER OF CONSERVATION JUDGEMENTS AT NON-CONSERVATION AND TRANSITIONAL LEVELS WHEN QUESTIONS REFERRED TO LENGTH, DISTANCE, AND TIME

Groups and Stages	No.	Max* No. of cases (N x 3)	Conservation judgements		
			Length	Distance	Time
Elcho					
I	31	93	13	12	18
II	9	27	12	11	17
Hermannsburg					
I	31	93	28	33	36
II	17	51	32	24	35

* All children not necessarily questioned in all cases.

TABLE 18

LENGTH

NUMBER OF CHILDREN TENDING TO JUDGE TOP STICK (MOVED) OR BOTTOM STICK (STATIONARY) LONGER WHEN QUESTIONS REFERRED TO LENGTH, DISTANCE, AND TIME

HERMANNSBURG GROUP

Judgements	Non-conservation cases N = 31 No.of cases = Nx3			Transitional cases N = 17 No.of cases = Nx3		
	Questions on			Questions on		
	Length	Distance	Time	Length	Distance	Time
Conservation judgements	4	6	1	32	24	34
Tendency to judge top longer	82	72	47	24	15	17
Tendency to judge bottom longer	5	10	30	6	9	14
Judgements inconsistent	1	4	8	-	1	-

TABLE 19

LENGTH

NON-CONSERVATION EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATIONS

Stages and Groups	No.	Non-conservation explanations[1]					
		A S	B P	C M	D I	E C	F D
Elcho							
I	31	13	3	-	1	3	2
II	9	2	1	1	2	-	-
Hermannsburg							
I	31	22	6	1	5	-	-
II	17	12	6	1	3	2	-
III	8	4	1	2	2	1	-

1 For description of explanations, see text p.271.

Note: Number of children giving contradictory explanations for judgements on speed (i.e., 'It's quicker because it's longer' or 'It takes longer time because it's shorter'.
Elcho, Stage I group - 8
Hermannsburg, Stage I group - 10.

S = Size.

P = Position.

M = Movement.

I = Irrelevant.

C = Contradictory (i.e., 'Same').

D = Different.

TABLE 20

LENGTH

CONSERVATION EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION, AND NUMBER OF CHILDREN RETURNING STICKS TO ORIGINAL POSITION TO DEMONSTRATE EQUALITY

Stages and Groups	No.	Conservation explanations[1]					Sticks put together	
		1 Correct		2 R	3 I	4 C	1 S	2 AQ
		E	Im					
Elcho								
I	31	-	-	3	1	4	-	NQ
II	9	1	1	4	2	1	-	
III	25	4	5	13	2	-	-	
Hermannsburg								
I	31	-	-	2	-	7	-	-
II	17	-	4	9	5	2	-	10
III	36	5	3	21	3	4	2	17

1 For description of explanations, see text p.273.

E = Explicit.

Im = Implicit.

R = Repetitive.

I = Irrelevant.

C = Contradictory.

S = Spontaneously.

AQ = After questioning.

NQ = Not questioned.

TABLE 21

LENGTH PART I

NUMBER OF CHILDREN AT EACH STAGE OF DEVELOPMENT

Groups	No.	Stages		
		I	II	III
Elcho	65	17	12	36
Hermannsburg	84	6	11	67

TABLE 22

LENGTH PART I

NUMBER OF CHILDREN GIVING AT LEAST ONE CORRECT JUDGEMENT WHEN QUESTIONS REFER TO LENGTH, DISTANCE, AND TIME

Groups and Stages	No.	1 Where end points coincide			2 Where ends of S/S overlap curved		
		Length	Distance	Time	Length	Distance	Time
Elcho							
I	17	1	3	5	-	1	3
II	12	0	6	12	-	1	8
III	36	11	30	36	7	27	36
Hermannsburg							
I	6	2	3	3	2	3	1
II	11	6	10	11	1	1	3
III	67	19	37	54*	4	33	67

* All children questioned (where answers correct on length and distance not necessarily questioned on time).

S/S = Straight stick.

TABLE 23

LENGTH

COMPARISON OF CLASSIFICATIONS ON PARTS I AND II

A. ELCHO GROUP

		PART I			
		I	II	III	Totals
PART II	I	12	8	11	31
	II	-	2	7	9
	III	5	2	18	25
Totals		17	12	36	65

B. HERMANNSBURG GROUP

		PART I			
		I	II	III	Totals
PART II	I	3	5	23	31
	II	1	1	15	17
	III	2	5	29	36
Totals		6	11	67	84

TABLE 24

AREA

SUB-CLASSIFICATION OF STAGES OF DEVELOPMENT

NUMBER OF CHILDREN AT EACH STAGE

Groups	Non-conservation levels				Main stages		
	A	B	C	D	I	II	III
Elcho N = 65	12	16	5	12	45	9	11
Hermannsburg N = 83	10	26	12	12	60	8	15

TABLE 25

AREA

EXPLANATIONS

NUMBER OF CHILDREN GIVING AT LEAST ONE OF EACH TYPE OF EXPLANATION

Groups and Stages	No.	Explanations[1]				
		NoE	R & I O	R to D	Referring to No. I	Referring to No. C
Elcho						
I	45	3	28	8	5	10
II	9	1	5	1	-	3
III	11	-	2	-	-	9
Hermannsburg						
I	60	6	19	11	-	23
II	8	-	4	-	-	4
III	15	1	3	2	-	11

1 For description, see text p.283.

NoE = No Explanation.

R & I O = Repetitive and Irrelevant only.

R to D = Refer to Distribution of houses.

I = Incorrect.

C = At least one correct.

TABLE 26

AREA

CLASSIFICATION OF CORRECT EXPLANATIONS ACCORDING TO NUMBER OF HOUSES FOR WHICH IT IS GIVEN

	No correct expls	Number of Houses							
		Number Unequal			Number Equal or Unequal				
		x/o	1/0	2/1	2-5	5-10	10-15	15-20	20+
Elcho									
I	10	1	7	2	-	-	-	-	-
II	3	-	-	-	1	1	-	-	1
III	9	-	-	-	-	3	2	2	2
Hermannsburg									
I	23	-	6	9	4	2	2	-	-
II	4	-	-	-	-	2	-	1	1
III	11	-	1	-	-	-	-	--	10

X/O = large number of houses on one field - none on the other.

1/0 = 1 house on one field - no houses on the other field.

2/1 = 2 houses on one field - 1 house on the other field.

2-5 etc. = 2-5 houses on each field, numbers equal or unequal.

APPENDIX 6

EXAMPLES OF TEST PROTOCOLS

The following examples of test protocols are taken from the tape recordings of these sessions. The recordings have been edited to cut out some unnecessary and tedious repetition, but otherwise are exactly as recorded.

Two examples of the test on volume have been chosen to illustrate conservation and non-conservation. The Elcho and Hermannsburg groups are distinguished by the letters E and H, and the first figure of the subject's code number indicates his age group.

Example 1. Subject H 9/5 Stage I - Non-conservation

Introduction

E. Do you see the water in these two glasses? Do you think the water in the two glasses is the same?

S. Yes.

E. Do you know what this is called? What is this?

S. Plasticine.

E. Plasticine. That's right. Now you see these two balls of plasticine. Do you think they're the same size?

S. No.

E. Which is bigger?

S. (Points to large red ball.)

E. Now what do you think would happen if we put this ball of plasticine (large red ball) into the glass of water? If we put it right inside the glass of water, what would happen?

S. Full.

E. Do you think that the water would come up full?

S. (Nods in affirmative.)

E. Why would the water come up full?

S. (No answer.)

E. If we put this ball (small brown ball) into this glass of water, what do you think would happen?

S. Full.

E. Would it come up the same high as in the other glass?

S. No.

E. Which one would come higher?

S. (Points to large red ball.)

E. Why would that come higher?

S. Big.

E. What is big?

S. Plasticine.

E. Let's put it in and have a look. We'll put the red ball into this glass. Watch the water. Did the water come up?

S. Yes.

E. Why did it come up?

S. Full.

E. What made the water come up?

S. Plasticine.

E. Now we'll put this little ball into this glass. Watch the water. Did the water come up?

S. <u>Yes</u>.

E. Did it come up the same high as in the other glass?

S. <u>No</u>.

E. Which one is higher?

S. (Points to glass with large ball.)

E. Why did that come higher?

S. <u>Full</u>.

E. What made this one come up full?

S. <u>Plasticine</u>.

E. Why did this plasticine in this glass make the water come up higher than this plasticine in this glass? (Repeat question several times.)

S. (Finally) <u>Heavy</u>.

<u>Part 1</u>

E. Now we'll take these balls out of the glasses. Now, you see these two yellow balls that we've got here? Do you think they are the same size?

S. <u>Yes</u>.

E. If we were to put that yellow ball into that glass of water, and that yellow ball into that glass of water, do you think the water would come up the same high?

S. <u>Yes</u>.

E. Why would it come up the same?

S. <u>Level</u>.

E. What is level?

S. <u>Plasticine</u>.

(The child is then asked what would happen if a yellow ball was put into one glass and the red ball into the other, and what would happen if the brown ball was put into one glass and the yellow ball in the other. Both these questions were answered correctly, and were supported by the explanation that the larger ball would make the water come higher because it was 'fat' or because it was 'big'. The comparison of the two yellow balls was then repeated, with exactly the same response as reported above; i.e., the water would come up the same because the plasticine was level.)

Part 2.

E. Now we're going to make this ball into a flat ball like this. We're going to push it down like this and make it into a flat ball. Now, if we were to put this round ball into this glass, and this flat ball into this glass, do you think the water would come up the same in the two glasses? If we put that one right inside there and that one right inside there, would the water come up the same?

S. No.

E. Which one would make the water come higher?

S. (Points to ball.)

E. Why would that one make the water come higher?

S. Fat.

E. I see. Do you think that the plasticine here in this one will be the same as this plasticine here?

S. No.

E. Which one will have lots?

S. (Points to ball.)

E. Why do you think that that one has lots? How do you know that that one has lots?

S. Fat.

E. I see. If we made this back again into a ball and if we put the two balls into the glasses of water, would the water come up the same in the two glasses?

S. Yes.

E. And now, if we put this flat one into this glass and the round one into this glass, would the water come up the same in the two glasses?

S. No.

E. Which would come higher?

S. (Points to ball.)

E. Why would that one come higher? (Repeat question.)

S. Heavy.

Part 1 (Repeated)

E. Now we're going to put this one back into a ball, like it was before. Now, if we put this ball into this glass, and this ball into this glass of water, do you think the water would come up the same in the two glasses?

S. Yes.

E. Why do you think that?

S. Level.

Part 3

E. Now look, we're going to make this ball here into a long one. We'll make it into a long one like this.

Now, if we were to put the round ball into this glass, and the long one (we'll turn it round like that and put it all inside), if we put the long one into this glass, do you think the water would come up the same in the two glasses?

S. No.

E. Which one would make the water come higher?

S. This one (ball).

E. Why would that one make the water come higher?

S. Fat.

E. Do you think the plasticine here in this long one will be the same as the plasticine here (in the ball)?

S. No.

E. Which has lots of plasticine?

S. (Points to ball.)

E. Why do you think that one has lots?

S. Fat.

E. If we were to put this long one back again into a ball, like it was before, and if we put the two balls into the two glasses. Do you think the water would come up the same in the two glasses? (Repeat.)

S. Yes.

E. And now, if we put this round one into this glass and this long one into this glass, do you think the water would come up the same in the two glasses?

S. No.

E. Which one would make the water come higher?

S. (Points to ball.)

E. Why would that one make the water come higher?

S. Fat.

Part 1 (Repeat)

E. Now look, we're going to put this back again into a ball. If we were to put this ball into this glass, and this one into this glass, do you think the water would come up the same in the two glasses?

S. Yes.

E. Why would it come up the same?

S. Level.

E. What is level?

S. Plasticine.

Part 4

E. Now look, we're going to break this ball into a lot of little peices. We're going to break up the plasticine into a lot of little pieces, like this. Now if we were to put this ball into this glass of water, and all these little pieces here into this glass of water, do you think that the water would come up the same in the two glasses?

S. No.

E. Which would make the water come higher?

S. (Points to ball.)

E. Why would that make the water come higher?

S. Fat.

E. Do you think that the plasticine here in these little pieces will be the same as the plasticine here (in the ball)?

S. No.

E. Which one will have lots of plasticine?

S. (Points to ball.)

E. If we put all these little pieces here into this glass, and the ball into this glass, would the water come up the same?

S. No.

E. Which would come higher?

S. (Points to ball.)

E. If we made it back again into a ball, if we put all these little pieces back into a ball, and if we put the two balls into the glasses of water, would the water come up the same in the two glasses?

S. Yes.

E. And now, if we put that round one into that glass, and all these little pieces into that glass, would the water come up the same?

S. No.

E. Which would come higher?

S. (Points to ball.)

E. Why would that come higher?

S. Heavy.

Drawings

E. Do you like to draw? Here we have some pictures of the glasses and the balls. This here is a picture of the glass. This line here shows where the water comes up. Do you see? It shows where the water comes to in the glass. Now if we were to put this red ball inside the glass of water; here is the red ball, and it's sitting inside the glass of water (indicating sketch). I want you to show me where the water will come when we put the red ball inside the glass. You draw the line to show where the water comes. That's right. Now we're going to put the little brown ball inside the other glass of water. There's the little brown ball inside the glass of water (indicating sketch). You draw the line to show where the water comes when we put the brown ball inside (levels drawn unequal). That's right. Now, we're going to put these two yellow balls inside the glasses of water. We'll put that yellow ball into that glass, and that yellow ball into that glass. Here are the yellow balls inside the glasses of water, you see (indicating sketch). You draw the line to show where the water goes when we put the yellow balls inside (draws for one sketch only). That's right, now show me for the other glass (levels drawn equal). Will the water be the same high in the two glasses?

S. Yes.

E. Now we're going to make this one into the flat ball again. Here is the round ball sitting inside that glass, and here is the flat ball, are you looking, here is the flat ball sitting inside that glass. You draw the line to show where the water comes when we put them inside the glasses. That's right, you draw the line in (said to encourage child, who is a little hesitant). Now show me where the water will come when we put the round ball inside (level drawn higher for the round ball). Do you think it will be the same in the two glasses?

S. No.

E. Which one will be higher?

S. (Points to drawing of ball.)

E. Why do you think that one will come higher?

S. Heavy.

E. Now we'll make this one into a long one like we had it before. Here is the long one inside the glass, and here is the round one inside the glass. You draw the line to show me where the water will come when we put them inside the glasses. And for that one (level drawn higher for ball). Do you think the water will be the same in the two glasses?

S. No.

E. Which one will be higher?

S. (Points to drawing for ball.)

E. Now we're going to break this one up into little pieces, like we had it before (repeat as for other cases). You draw the line to show me where the water will come (level drawn higher for ball). Will the water be the same in the two glasses?

S. No.

E. Which one is higher?

S. (Points to drawing of ball.)

E. Why is that one higher?

S. Fat.

Example 2. Subject H 9/6 Stage III - Conservation

Introduction

E. Now, you see these two glasses of water here? Do you think the water in the two glasses is the same?

S. Yes.

E. Do you know what this is here? What is this called?

S. Plasticine.

E. That's right. Now you see these two balls of plasticine. Do you think that they are the same size?

S. No.

E. Which one is bigger?

S. (Points to red ball.)

E. What do you think would happen if we put the big ball of plasticine inside the glass of water? What would happen to the water?

S. It would get wet.

E. But do you think the water would stay just like that, where it is, or do you think it would come up higher? Do you think the water would come up higher when we put the ball in?

S. Yes.

E. Why do you think the water would come up higher?

S. Because this ball is in.

E. And if we put this little brown ball into this other glass here, what do you think would happen?

S. It would get wet.

E. And what would happen to the water?

S. It would go up.

E. Would it come up the same as for that ball (large red)?

S. No.

E. Which ball would make the water come higher?

S. (Points to large red ball.)

E. Why would that one make the water come higher?

S. This one is big.

(Balls are put inside the glasses to demonstrate, and the child is questioned as before. His answers are the same as in the case of his prediction.)

Part 1

E. Now you see these two yellow balls. Do you think they are the same size?

S. Yes.

E. If we were to put that ball into that glass of water, and that ball into that glass of water, do you think the water would come up the same in the two glasses?

S. Yes.

E. Why do you think it would come up the same?

S. The balls the same size.

(The child is then questioned as to what would happen if the red ball was put into one glass, and the yellow ball in the other, and what would happen if the brown ball was put into one glass, and the yellow ball in the other. He answers correctly for both questions that the larger ball would make the water rise higher, giving the explanation 'Because it is big' in both cases. The comparison between the two yellow balls is then repeated, and the child states that the water will come up the same high for both balls 'Because the two balls are the same'.)

Part 2

E. Now look. I'm going to make this ball flat, like this. I'm going to push it down, and make it flat. Now if I were to put this round ball into this glass, and the flat one into this glass, do you think the water would come up the same in the two glasses?

S. Yes.

E. Why do you think it would come up the same?

S. I see this one was round like that.

E. Do you think that the plasticine here in this flat piece will be the same as the plasticine here in this round ball?

S. Yes.

E. How do you know it is the same?

S. I see this one was round first like this one.

E. If we put the round one into that glass, and the flat one into this glass, do you think they will make the water come up the same?

S. Yes.

E. Or do you think one will make the water come higher? Will one of these make the water come higher than the other?

S. No.

E. How do you know it will come up the same?

S. Because this one was round like this one.

Part 3

E. Look, we're going to make this one into a long one. We're going to roll it out, see, and make it into a long one. Like that. Now, if we were to put this round ball into that glass, and this long one here, we'll put it around and around so that it all goes into the glass (twisting it around), if we put the long one all into that glass, do you think the water would come up the same in the two glasses?

S. Yes.

E. Or do you think one would come higher?

S. The same (very definitely).

E. How do you know it would be the same?

S. I see this one was round like this.

Part 4

E. If we break this one up into little pieces, we break it all up into little pieces like that so we've got lots of little pieces. Now if we put this round ball into this glass, and all these little pieces into this glass, do you think the water would come up the same?

S. Yes.

E. Why do you think it would come up the same.

S. This one was round like this one.

E. And do you think that this plasticine here will be the same as the plasticine here, or do you think that one lot will have more plasticine?

S. Same.

E. And if we put these pieces into that glass, and the round one into that glass, which lot do you think would make the water come higher?

S. The same.

Drawings

(The sketches were explained to the child in exactly the same way as in the previous example, and he was asked to draw the levels in for each case. The levels were drawn unequal for the large red ball and the small brown ball, but equal in all other cases. In Part 3 he drew a faint line across from the one sketch to the other to mark the same level for the two glasses. He was asked in each case if the water would come up the 'same high', and answered correctly in all cases. He was not asked for any further explanations, since at this point it seemed quite unnecessary.)

Transitional Level

A complete recording of the responses of a subject at the transitional level is not available, but to illustrate this level the following example is taken from the score sheet. In this case the experimenter's questions have been considerably abbreviated and the inessential comments have been excluded. All the subject's answers and explanations were recorded as fully as possible.

Example 3. Subject H 15/10 Stage II - Transitional

(In the Introduction, the child correctly predicted that the water would rise if the large ball was placed inside the glass 'Because the plasticine is big', and that the water would come up a little when the small ball was placed in the glass because 'The plasticine is small'.)

Part 1 (Two equal sized balls)

E. Same? (i.e. Would the water rise to the same level in the two glasses if the two equal sized balls were placed inside.)

S. Yes.

E. Why?

S. The plasticine are both same.

Part 2 (The ball compared with the flattened plasticine)

E. Same?

S. Yes.

E. Why?

S. The plasticine is same size.

E. How do you know that?

S. This one was same before.

Part 3 (Ball compared with long)

E. Same?

S. No.

E. Which will make the water come higher?

S. The ball.

E. Why?

S. <u>Because it is round</u>.

E. Is the plasticine (in the ball and the long one) the same?

S. <u>Yes</u>.

E. Or does one have more plasticine?

S. <u>No</u>.

E. How do you know that?

S. <u>They were the same before</u>.

E. And would they make the water rise to the same level?

S. <u>Yes</u>.

E. Or would one make the water rise higher?

S. <u>No</u>.

E. Why?

S. <u>They are both same</u>.

<u>Part 4</u> (Ball compared with pieces)

E. Same?

S. <u>Yes</u>.

E. Or will one make the water come higher?

S. <u>No</u>.

E. How do you know that?

S. <u>The plasticine are both same</u>.

E. How do you know that?

S. <u>They were same before</u>.

Drawings

Drawing 1 (Large and small ball)

Levels drawn unequal.

Drawing 2 (Equal sized balls)

Levels drawn equal.

E. Will the water come the same high in the two glasses?

S. Yes.

Drawing 3 (Ball and flat)

Level for ball drawn slightly higher.

E. Will the water come the same high in the two glasses?

S. No.

E. Which will make the water come higher?

S. The ball.

E. Why?

S. Because the ball is round.

Drawing 4 (Ball and long)

Level for ball is drawn quite clearly higher than the level for the long plasticine.

E. Will the water come up the same high in the two glasses?

S. No.

E. Which will make the water come higher?

S. The ball.

E. Why?

S. Because the plasticine is round.

Drawing 5 (Ball and pieces)

Levels drawn approximately equal.

E. Will the water come up the same high in the two glasses?

S. Yes.

E. How do you know that?

S. This one was same as this.

Following this response the subject was questioned again on Drawing 4.

E. And in this drawing, do you think the water will come up the same high in the two glasses?

S. No.

E. Which will make the water come higher?

S. The ball.

E. When we had the long plasticine, did the long plasticine have the same amount of plasticine as the round ball?

S. Yes.

E. So would they make the water come up the same high?

S. No.

E. Which would make the water come up higher?

S. The ball.

E. Why?

S. Because the ball is round and heavy.

The questions are then referred to Drawing 3.

E. And in this drawing, would the flat one make the water come the same high as the round one?

S. No.

E. Is the plasticine the same?

S. Yes.

E. And would the water come up the same high?

S. No.

E. Which would make the water come higher?

S. The ball.

E. Why?

S. Because the plasticine is round.

APPENDIX 7

PROPOSAL FOR STUDY OF ORDER EFFECTS

No systematic study of the effects of order in the presentation of Piaget-type tests has been reported. These effects are relevant to a number of the problems that have been raised by the investigations based on Piaget's work, which have been discussed in Chapter IX. A systematic study of order effects would help to resolve some of these issues, and would be important for the investigation of whether or not Piaget's tests can be used to establish a natural ordinal scale of intellectual development.

A proposal for such a study is outlined below.

I. Proposed design for the study of variations in the effects of experience with age, stage of development, and intelligence.

Our findings and those reported by other investigators (e.g., Beilin and Franklin [1962]) have suggested that the effects of experience in the test situations (i.e., order effects) may vary according to the age, stage of development, and intelligence of the child.

A study of these effects could be carried out as follows:

1. Pre-test a group of children from, say, five to seven years, on one test, e.g., Conservation of quantity. (The age would depend on the group of children tested and the tests to be used.)

2. Apply a standard intelligence test.

3. Classify the children according to age, stage of development, and intelligence. For a group of children from five to seven years the following categories would be distinguished:

<u>Age</u>	5 years	6 years	7 years
<u>Stage</u>	Non-conservation	Transitional	Conservation
<u>Intelligence</u>	High I.Q.	Medium I.Q.	Low I.Q.

This classification would give a total of 27 groups. In order to have approximately equal numbers in each group some selection from the initial group pre-tested would be required. If a minimum of approximately five children in each group were set, the final sample would consist of approximately 135 children.

4. Apply a series of five or six tests. These tests should be of approximately equal difficulty, and for a five to seven year old age group should be based on concrete operational structures.

5. Apply a post-test to all the children. This could be a repeat of the initial test, or a variation of the same basic problem.
(The purpose of this proposed study is to investigate the variations in improvement from pre-test to post-test according to age, stage and intelligence. However, if one wished to determine whether improvement was due to practice effects [i.e., practice on the pre-test alone] or to generalization [i.e., experience on the

intervening tests] it would be necessary to test a control group on the pre-test and the post-test only.)

6. Measure improvement from pre-test to post-test in terms of percentage achieving conservation, or in terms of percentage showing improvement (i.e., including improvements from non-conservation to transitional responses).

7. Apply Sutcliffe's (1957) method of multiple contingency analysis to study the interaction between improvement from pre-test to post-test and each of the other variables (i.e., age, stage, intelligence and the interactions between these variables). (Sutcliffe's example [2b] would be applicable to this case.)

II. Proposed design for the study of sequential and positional order effects.

If a series of tests is administered to a group of subjects the performances on any particular test may vary according to:

1. The number of tests which have preceded it (i.e., its rank order or position).
2. Which particular tests have preceded it (i.e., its sequential order).

In a series of Piaget-type tests we would expect both positional and sequential order effects to be operating. For example, in the case of the tests on quantity, weight and volume, performance on the test on weight may vary according to whether it is presented first or second in the series, and according to whether it is preceded by the test on quantity or the test on volume.

It would also be expected that order effects would vary according to the particular test involved. For example, little or no improvement with experience may be found for the more difficult tests, such as area or volume, regardless of how many or which tests have preceded them, while other tests such as quantity may show very marked improvements with experience.

Studies of the effects of positional or sequential order and the particular test involved could be undertaken as follows:

A. Positional order

A series of tests would be administered to different groups of children so that each test is administered in each possible rank order. Using a Latin square design, the number of groups required would be equal to the number of tests in the series. The tests included could be of varying difficulty, and depend on both concrete and formal operational structures.

For a series of six tests (e.g., conservation of quantity, weight, volume, length, area and number) the procedure would be as follows:

1. Administer a pre-test to a group of children of the required age.

2. Apply standard intelligence test.

3. Select six groups matched for age, stage of development and intelligence. (The sample should be restricted to the age, stage and intelligence levels where the effects of experience are most consistent, and separate studies should be undertaken for those groups where order effects vary markedly with these factors. About 10 to 20 children could be included in each group.)

4. Administer the series of tests in the six different orders to the six matched groups.

5. Apply Sutcliffe's method of multiple contingency analysis to study the interaction between success on each test and positional order, the test involved, the group of subjects, and the interactions between these three variables. (Sutcliffe's example [2b] would be applicable to this case.)

B. Sequential order

In this case, the tests would be administered to separate groups of children in each possible order and sequence.

Such a study could only be carried out for a series of three to four tests. The number of groups required for any series greater than this would make such a study impractical.

A study of sequential order effects would be particularly suitable for the tests on quantity, weight and volume. For a series of three tests there would be six possible sequential orders.

The procedure for such a study would be precisely the same as in A above, but in this case sequential order would replace positional order effects. The same method would be applied to the analysis of the results.

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