I N V A R I A N C E : A STUDY OF SOME CONSERVING BEHAVIOURS IN YOUNG CHILDREN

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ABSTRACT

Piaget's theory of intellectual growth describes the child as the architect of his own thinking. The child's initial thought patterns are perception-oriented interpretations of the surrounding world. As his experiences continue they are transformed internally by the child's previous storage level of understanding. This introspection leads to a gradual but spectacular change in the basis of thinking, there is a move from semilogic to rationality. Each act of understanding involves an element of invention which has had no existence before either in the external world or in the subject's mind. The concept of invariance is central to Piaget's theory. It concerns the individual's recognition that a change in an external dimension does not imply a change in quantity unless something has been added or removed.

The fieldwork section of this study provides an examination of some of the known necessary conditions for conserving behaviours. The New Zealand sample followed the pattern outlined by Piaget; many young subjects were included in the group of non-conservers, a middle group of borderline conservers were more likely to conserve quantity than volume, and the third group of subjects were assured conservers and included

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fewer younger subjects in their number. These findings are used to illustrate some aspects of the current literature on the necessary conditions for invariance.

The child, who has access to a wide range of recognizable operational variety in his environment, whose experience has undergone some internalized ordering, who has confidence to explore his world, whose present equilibrated structures can make an adjustment to a mismatch, is likely to develop conserving behaviours. The significance of the semiotic function rather than the specific dominance of language is discussed in the study. Piaget recognizes the extending role of language but demonstrates that invariance can be established without language but not without operations.

The sufficient conditions for conserving are not yet definitive, they do arise from the child's active involvement with his environment. The present studies are based on post hoc explanations concerning particular aspects of invariance. The concept is a comprehensive understanding but the current measures are centred on specifics of the whole. Some of the sufficient conditions include the preliminary recognition of permanency of objects which contributes to the identity element in conservation, identity and equivalence by compensation and reversibility are the accepted (sufficient) conditions for invariance in contemporary terms.

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The final section examines some of the implications for educators. Teachers have the task of providing individual children with operational challenge. The failure of many studies which attempt to influence a child's conserving responses by language and operational training is salutory.

Special thanks are due to Prof. C.G.N. Hill, Dr D. McAlpine, the District Senior Inspector, Wanganui Education Board, the Principals, Teachers and Pupils of the schools of the Wanganui area for their considerate and encouraging support during the preparation of this paper.

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PART I : THEORETICAL BACKGROUND

"The ability to conserve, which is acquired as a result of the decentration of the child's attention, is supported by three types of operation which are sometimes explicitly expressed in the child's justification of his response : reciprocity, negation and identity."

(Ginsberg & Opper 1969)

(A) Purpose of this Study

This investigation is concerned on one hand with a brief appraisal of Piaget's theory of conservation and on the other with the analysis of responses to the conservation tasks from a group of Maori and European children. These children were enrolled in junior classes in the Wanganui area. This survey was part of a cross cultural study on the acquisition of conservation concepts undertaken in association with Prof. Murray, University of Delaware (1968 (a)).

The study is based almost exclusively on Piaget's theory of intellectual development, as 'conservation' is a section of that general theory. The views of Chomsky (1968) who argues for the innateness of intellectual structures, Bruner (1960) who emphasises learning by discovery and Elkind (1969) who has restated some of Piaget's thinking on invariance, will receive some recognition.

There is a vast amount of recent research on the topic of conservation. Most researchers endorse

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and amplify Piaget's ideas and a small number are using these constructs as a springboard for future refinement.

The initial purpose was to pinpoint the behavioural landmarks which contribute to the acquisition of conserving behaviour. Later the route moved from an examination of sufficient conditions for conservation to a statement of some necessary conditions for this behaviour. The following questions gave the direction of the work.

(1) RECOGNITION : how does the child recognise that a situation exists; in this case to conserve or not to conserve?

(2) AREA and BOUNDARY : once the field for action is in focus, how does a child decide what situations are concerned with conservation and what are not?

(3) EXTENSION : when a conserving situation is actioned, how does the child generalize these ideas into wider situations?

(B) Conservation

"Conservation has thus to be conceived as the resultant of operational reversibility".
(Piaget 1971)

When Crick and Watson were unravelling the structure of the DNA molecule they were continually baulked by the disparity between their interpretation of the data available and the evidence from infra-red photography. The classroom setting provides a daily parallel to that puzzle. In all Junior Schools there

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is a continuous stream of response patterns based on the pupils' developmental stage. The difference in thinking patterns ranges from those pupils who can provide rational grounds for some of their judgements to those whose thinking is largely dominated by the appearance of things. Conservation is the Piagetian term to describe the premier milestone in the development of logical thinking; it concerns an operational process of the mind. There is a gradual emergence of an understanding that certain aspects of a changing condition are unchanging despite those changes. It is possible to describe children's thinking in terms of their ability or inability to conserve. The study of this change in perspective has given rise to a vast literature of theories and research projects, but the dynamics of the change still present an enigmatic shadow of the reality.

The route between operational and logical thought is, in large measure, controlled by the individual's ability to conserve. The changing basis for decisions is not clearly marked or irreversible in the early stages, the kinetic charge comes from the child's own activity. There is a time of hesitation but once the ability to recognise the invariance is established for that particular context there is no return to the illogical bases which gave assurance to previous judgements.

Conservation is an individual and universal development in man's thinking. The Geneva school stresses several important elements in this growth.

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It is the outcome of an extensive action-reaction-modification circuit. Each individual manufactures his own patterns of thinking; they do not arise from the environment or in a void, but their construction stems from earlier patterns. The elaboration of these patterns may extend over many years.

> "The process (of conservation) is completed by about the age of seven and is then followed by an equally long process of structuration."
>
> (Barbel Inhelder 1969)

The patterns are not regarded as fortuitous, but their growth is governed by particular laws at specific times.

> "it is more difficult to order serially, to equalize objects whose properties are less easy to dissociate from one's own action, such as weight, than to apply the same operations to properties which can be objectified more readily such as length."
>
> (Piaget 1958)

The dynamic for these developments issues from the thought patterns themselves. As the structures become more elaborate their framework demonstrates an incomplete reconstruction of reality, so that the individual is compelled to formulate a more sophisticated construct.

(C) THE CONSTRUCTION OF CONSERVATION

(i) Man and Environment

Piaget refuses to separate man and environment since he views one without the other as an inoperative situation. The growth of intelligence is concerned with the active construction of the individual as he

lives in the process of his development

> "...it is the constant duality of always being simultaneously structuring and structured that accounts for the success of the notion of law or rule employed by the structuralists."
>
> (Piaget 1971)

(ii) Logical Structures

The magnitude of observation and experiment from Piaget's work supports his belief that logical structures are constructed. They take many years to mature, their construction is controlled by a network of special laws, and this construction always initiates further learning.

The blueprint for conservation begins in sensorimotor intelligence. There are a limited number of reactions already present at birth. They include sucking, looking, listening, vocalising, grasping and motor activity of the trunk and limbs. These activities do not emerge spontaneously at birth. Their presence at the pre-natal stage has been well documented, including a recent Auckland study by Prof. Lilley (Massey lecture 1970). The reactions are not a selection, in miniature, of the range available to the individual throughout life. They are the prime components to be specialized and differentiated through the activity of the individual and his environment. This notion of complex transformations developing from a limited initial system is not unique to logical thinking as it is shared by other studies. Ashby's (1952) "Design for a Brain",

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G. Walter's study of brain patterns, and the term 'regulation' in the area of cybernetics have a similar basis (Furth 1969). Piaget terms these initial structures "general co-ordinations of actions". Their significance is not that they are innate but that they become differentiated by functioning.

(iii) Structure-function route

The rhythm of structure development has a dual structure-function and control. The functional factors are assimilation (an action is actively reproduced and may include new objects into itself) and accommodation (applying schemes of assimilation in modified way to other objects). The structural elements include certain order relationships, the subordination of schemes from simple to complex and the production of correspondences. (Piaget 1971)

(iv) Structural elements

It is not until quite late in sensori-motor thinking that there is evidence that the child is capable of seeking an object when it is no longer present or he may be able to use some part of his environment to cause a reaction. Piaget describes these actions as resulting from a co-ordination of primary assimilation schemes.

> "...certain equilibrated structures, those that make for a modicum of reversibility become established."
>
> (Piaget 1971)

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To play hide-and-seek or peek-a-boo is a pre-requisite for the award, 'permanency of objects'. Uzgiris and Hunt (1968) have developed

> "...a clear ordinal scale of behavioural landmarks in this development of object permanence."
>
> (Elkind 1969)

The child now possesses some primitive appreciation of the logic of order, inclusion and correspondence. This 'early' conservation may show a tendency to appear and disappear but the schemata persist longer and stronger as the perceptual encounters are increased and multiplied.

> "...like the point in a gravitational field around which actual and potential acts of knowing stand in equilibrium."
>
> (Furth 1969)

The child's order relationships are totally immersed in sensori-motor schemes, his sub-ordering schemes are implicit and his correspondence activity is primitive. His goal-seeking and detour behaviour sets, give examples of the beginnings of reversibility in thought.

Representational thinking appears during later sensori-motor development and as the child's growth in imagery, speech and symbolic play increases he reaches a new frontier of both power and bewilderment.

> "The child may be able to think of something but it does not by itself give him the means to comprehend the object."
>
> (Furth 1969)

The ability to represent ideas permits the development of reflective abstractions. As pre-operational development continues the child shows an increasing ability to order and rank. His subordination schemes

/are more

are more refined so that there is a distinct classification, his correspondence schemes may include one to many, one to one, or copy to original. Inhelder describes this as a time of 'semi-logic'. The notions of function and identity are present but the ability to think reversibly is yet to come.

> "A true notion of conservation is a construction that rests on a fully reversible system of knowing."
>
> (Furth 1969)

Conservation presages the onset of concrete operational thinking, and development is continuous until thought patterns are extinguished. The route began with object permanence and progressed by transformation activity to operational knowing. The child is now able to order materials with an appreciation of reversibility in relationships; subordination schemes are more complex and correspondence schemes include semi-networks. There is an assurance in the child's response to the invariance of quantity regardless of the external arrangement because he is able to classify and to reverse operations mentally.

> "Piaget contends that a correct judgement of conservation is the result of a compensating transformation."
>
> (Furth 1969)

Concrete operational thinking, in Furth's terms, has a double emphasis. He names the groupings as 'a hierachy of classes' and 'a grouping relations'. At first they are the separate systems and there is reversibility in both systems but as the groupings extend and interweave the thinking patterns become formal operational.

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(v) Equilibration and Conservation

Piaget designates four factors in intellectual growth. Three involve the individual as a receptor. They are maturation, experience and social transmission. The fourth factor, equilibration, concerns the individual's response to the first three. This is the self-regulating mechanism which conducts the balance between the twin functional factors, assimilation and accommodation. The processing of new information and its incorporation as part of the individual's new mental structure results from equilibration. It concerns regulating and organizing schemes towards operations.

The term has a similar set of properties in biology and in cybernetics, where it is used to describe processes with feed back and feed forward qualities.

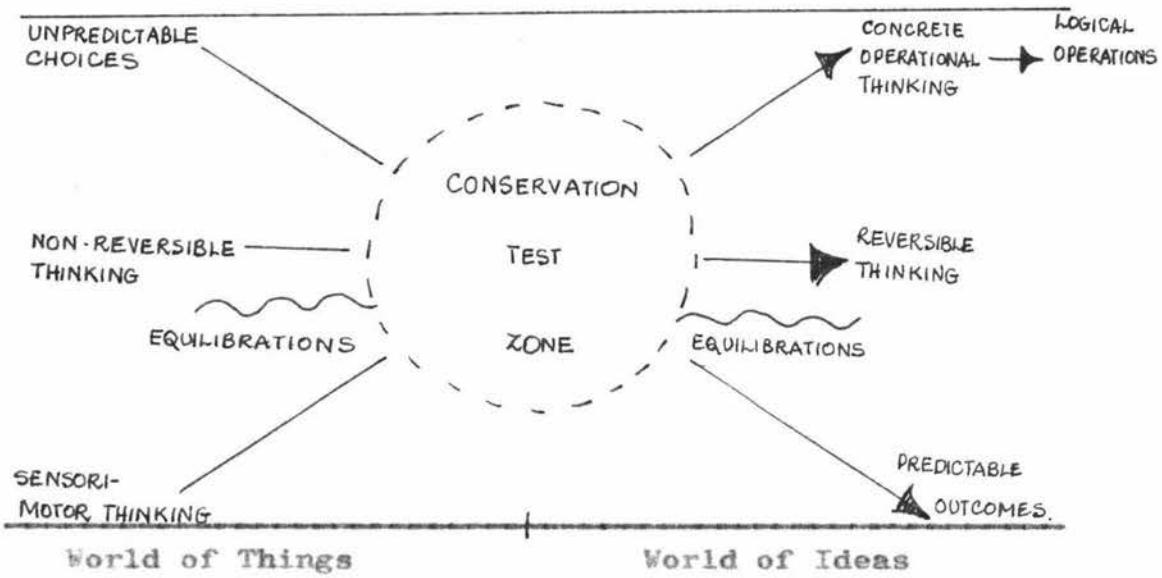
> "The concept of equilibration implies not only a constant development from less to more stable stages of equilibration but precludes the notion of a static beginning or end product."
>
> (Furth 1969)

The development of conservation results from a continuous network of equilibrations, not all of these proceed in a positive direction, some equilibrations preserve the status quo, others halt development until some irregularity of fit causes the individual to re-assess his earlier decision. The route is an individual specific one, but the direction is always 'toward order rather than chaos' (Inhelder 1955). Furth stresses the dynamic of equilibration when he describes the struggle for 'compensating mechanisms' by which children in the

/transition

transition stage toward reversible operations, seek to order their understandings. They cannot recognize an incongruity until their present level of thought is 'sufficiently receptive to the need for stability' (Furth 1969).

FIGURE A DIAGRAMMATIC REPRESENTATION OF INVARIANCE.



Piaget's concept provides an interpretation for the intrinsic form of causality within a total organism and an organizational law to explain the growth of thinking towards logical operational thinking.

(D) SOME RECENT RESEARCH

> "To divide developmental continuity into stages recognizable by some set of external criteria is not the most profitable of occupations, the crucial turning point for the beginning of operations shows itself in a kind of equilibration which is rapid and sometimes sudden, which affects the complex of ideas forming a single system and which needs explaining on its own account..."
>
> (Piaget 1950)

/Piaget

Piaget develops the theme that although there may be some similarity with the Gestalt theory the transformations which occur, in fact, often restate the relationships in startlingly new ways.

The implications from Piaget's work for teaching have not escaped the educations or the curriculum 'mandarins' (Marsh, 1970). There has been an immediate interest in the possibility of ordering the encounters that subsume behavioural change and to achieve some understanding of the 'ages' at which these landmarks could be expected.

Hunt (Elkind & Flavell 1969) considers that the traditional learning experiments provide examples of the immediate effects of short-term encounters whereas the effect of long-term encounters may be a more fruitful area to discover the role of experiencing in the modification of behaviour. Hunt has examined the contemporary attempts to encourage conservation and his findings follow.

A. So far short-term encounters are seldom effective (Gruen, Smedslund (many experiments), Elkind and Flavell 1969). There are particular cases where there has been an effective programme. These have involved short-term encounters confined to particular activities.

(1) Beilin, Gruen, Ojemann and Pritchard have had success when the children have been taught verbal rules. It has been well established that the ability to give verbal rules often enables a high resistance to conservation responses. Bruner and Inhelder have produced similar findings in some recent Harvard experiments.

(Furth 1969)

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(2) Smedslund's experiment involved teaching addition and subtraction as reversible intellectual operations where one nullifies the other.

(3) Beilin and Franklin found that the transfer is better from non-conservation to conservation when some indication of concrete operational thinking was already present.

B. The long-term experiments give evidence that experiences could influence the 'age' at which behavioural landmarks appear. Success in this area is dependent on the conceptions of cognitive structure, of conflict and of match which arise from Piaget's theory. (Kohlberg 1968)

Some successful long-term experiments include:

(1) Wacks, Uzgiris and Hunt (1967) have worked with deaf children.

(2) de Lemos (1967) has researched the culturally deprived children and young adults. In this work 'long-term encounter' was contact with European culture through schooling. These children scored significantly over their colleagues. In contrast to this study, Mermelstein (1964) working with Prince Edward County negro boys and Goodnow (1966) comparing schooled and unschooled Hong Kong children, both found no significant difference between the schooled and unschooled groups.

(Kohlberg 1968)

However, both studies provide direct evidence in support of long-term 'experiencing' encounters, the Smedslund study (1961 - reprinted Sigel & Hooper 1968) also provides some indirect support.

Hunt has criticised the Piagetian studies because they appear to test a particular area of conservation and then accept a general finding.

/However

However, the work of Laurendau & Pinard (Piaget 1970) on geometry and spatial representation exhaustively endorsed Piaget's findings on open and closed figures. Smedslund has investigated individual performances across a range of diagnostic tests of concrete operation and so far he has not found a consistent pattern. The landmarks are real but the routes are obscure.

When Hunt (Elkind & Flavell 1969) has examined the inferences from these studies he makes the following statements.

The landmarks of conservation may be said to occur through long-term repeated encounters with certain kinds of problem circumstances. The nature of these are still indistinct but the elements of surprise and spontaneous interest are worthy clues. The 'problem of match' provides another signpost (Berlyne 1961,1965). Hunt provides the lines of interest as;

(a) relevance to what child has already assimilated

(b) the encounter can be novel but not too strange

(c) they (encounters) should be sufficiently complex to modify existing understandings but not beyond these limits.

(Elkind & Flavell 1969)