A PIAGETIAN PROGRAMME OF INTERVENTION: FACILITATION OF CONCEPTUAL CHANGE AND COGNITIVE GROWTH

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PSYCHOLOGY

BY

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NOVEMBER, 1980

JOANNE,

MOM and DAD BURT,

For Your Unfailing Support

And Confidence.

"The long years of education are mostly concerned with knowledge. Fact is piled upon fact and little if any time is spent with the basic techniques of thinking. Skill in thinking is treated as a by-product that ought to follow detailed attention to specific subjects. But does it? And if it does, is not this a round-about and wasteful process - like burning down a pagoda to produce roast pork? On the whole, it must be more important to be skillfull in thinking than to be stuffed with facts."

- E. De Bono (p.7); The Five-Day Course in Thinking (1968)

ACKNOWLEDGEMENTS

I wish to acknowledge the following persons whose help and concern enabled this thesis to reach completion.

Professor H W Page - for helping me rediscover Psychology in the world of Piaget; for his guidance, understanding and supervision.

Dr C R Stones - for assistance with the manuscript.

Mr R G T Arnott

Mr J B Murray - for technical assistance and advice.

Mr E A Parsons

Mr E Goceni - for interpreting and finding subjects.

Pam McKenzie - for the fine effort of typing the manuscript.

Rhodes University - for much appreciated financial assistance.

Special thanks to all those who participated in the interviews.

ABSTRACT

This research aims (within a strictly Piagetian framework) toward the development of a programme of intervention which will facilitate cognitive development, conceptual change and scientific literacy for those individuals who experience difficulty in coping with contemporary scientific and technological concepts.

The research focuses specifically on the development of a diagnostic battery useful for realising a conceptual profile of the individual. This profile would indicate personal areas of functional interests that can be used creatively as a starting point for the facilitation of cognitive growth. The goal of such a programme is not the acceleration of cognitive growth, but rather the restoration of the individual to the mainstream of transactions in which the process of growth can flourish. The proposed facilitatory programme makes use of Piagetian tasks in a voluntary, individualist mode of instruction comparable to recently developed techniques of scientific education programmes.

In brief, this research analyses three specific areas:

1) The development of a body of theory that

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can assist in the development of such a facilitatory programme;

2) The development of a diagnostic battery to provide insight into the individual's level of conceptual development;

3) The realization of certain guidelines for an instructional procedure whereby facilitation of growth can begin.

The experiment takes the form of a pilot study of twentyfour black and white subjects, exploring whether the battery of Piagetian tasks reveals a profile of conceptual development of the individual.

Unique conceptual profiles were realized for all individuals, with evidence pointing towards the existence of a relationship between functional interests and the more advanced areas of the individual's conceptual development.

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AN OVERVIEW OF JEAN PIAGET'S THEORY OF COGNITIVE DEVELOPMENT.

1. PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

The one-celled animal responds to its environment in a very limited way, whilst the complex animal at the expense of biological simplicity enjoys more 'flexibility' being composed of many complex interrelated parts - some being specialised for the reception of information from the environment, whilst others for action on the environment. In adjusting and adapting to the environment the animal survives. However, not only are parts needed for the reception of information, and for acting on the environment, but also a 'mediating system' that can integrate the activities of these parts. Once an organism has developed this 'mediating system', the path is open to the development of alternative arrangements of behaviour. Thus, an individual's behaviour is influenced both by the reception of information and by the way his 'mediating system' or central organising processes, are structured and organised.

Piaget's genetic epistomology is to be seen as a cognitive rather than an associativistic theory, concerning itself with the central organising processes in cognitive development of higher animals in such a way that the animal becomes an actor rather than simply a reactor to its environment. Piaget's theory is seen as

../"interactionist"

"interactionist" or "constructivist" in that the organism inherits a genetic programme providing it with the biological potentials and equipment necessary (via a process of maturation) to gradually enable the organism to contruct a 'stable' internal structure - or "intelligence" - which then paradoxically assists the organism to adapt to the changes in its environment, the consequences of which may influence the organism towards further development. Piaget thus parallels organic life with intelligence, and phylogeny with ontology insofar as they are all biological functions involving adaptation and organisation.

1.1 ADAPTATION

Every living organism must be adapted to its environment for it to survive. To achieve this adaptation it must both assimilate its environment and accommodate to it. Assimilation can mean, biologically, taking in food and nutrients from the environment in order to maintain life. However, this process would prove futile if the organism were not able to make use of these nutrients towards an appropriate end such as producing energy and growth. In order that

.../the

the organism may make successful use of assimilated nutrients, the structure and the function of the organism must be adjusted or accommodated. In other words, by accommodating itself, the organism must have the working apparatus to assimilate. Thus, accommodation always involves the potential to modify the internal structure in such a way that the assimilatory process may continue, allowing survival in accordance with the immediate environmental contingencies.

> "Very generally, assimilation is what the organism has to do to remain alive and accommodation is how it does it. Yet it must be emphasised that these are only concepts, for in practise the two processes can never be separated. Adaptation prevails when there is a state of equilibrium between these two such that an organism, or a species, has its assimilatory needs balanced by its accommodatory capacities." (Russell, 1978, p.93).

Piaget describes cognitive development as a process of adaptation to the environment through the organisation of experiences. Knowledge in Piagetian

.../terms

terms is not a copy of reality, but the result of an operation - it is based on action.

> "To know an object, to know an event, is not simply to look at it and make a mental copy or image of it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed. An operation is thus the essence of knowledge; it is an interiorised action which modifies the object of knowledge."
> (Piaget, 1964, p.176)

Cognitive development, then arises out of an adaptive interaction between the organism and the environment, controlled by assimilation and accommodation. In other words, an individual gains knowledge of the world by acting upon the objects of the world and discovering the relationships and properties of these objects. These actions are interiorised and assimilated into a general strategy of action, or cognitive structure, whilst at the same time these structures must be accommodated to the assimilated information.

.../If

If the structures are not accommodated towards allowing the information to be assimilated, the individual experiences himself to be in a state of 'imbalance' - or in practical terms, unable to understand the information - and he will then attempt to reorganise (accommodate) his cognitive structures in such a way that the information can be assimilated; thus adapting to the environmental contingencies. It can be seen then that cognitive development is not an automatic process, for the individual is continually actively correcting and restructuring his plans and categories.

Assimilation and accommodation are always pushing in opposite directions with assimilation being conservative, structuring the present in terms of past experiences, whilst accommodation is innovative, restructuring the present and thus influencing future development. As Russell (1978) points out, intellectual adaptation begins via the processes of assimilation but is only able to succeed by virtue of accommodation.

1.2 ORGANISATION

A further biological function that Piaget parallels

.../with

with intelligence is the notion of organisation, without which adaptation could not take place. Organisation involves the relating of parts to the whole in such a way that one part is responsible for the successful functioning of the whole, and the continued functioning of the part is dependent upon the functioning of the whole. For example, a vital organ in the body, if removed causes death, but can only continue to function itself if all the other organs of the body cooperate and support it. Similarily with cognition - every structure that is constructed is in some way related to all other cognitive structures that have been created, and intelligent behaviour depends upon the interrelations of these structures.

Piaget points out that although an interiorised action (an operation) makes up the logical structures, it is a particular kind of action - a <u>reversible</u> action - which can take place in both directions. For instance, adding or subtracting, joining or separating. Operations can never be isolated, but are always linked to other operations and consequently the operation is always a part of a total structure. Logical class, for instance, does not exist in

.../isolation

isolation, but exists within the total structure of classification. Thus, as these operational structures constitute the basis of knowledge, the central problem of development is to understand the formation, the elaboration, the organisation and the functioning of these structures.

1.3 FOUR MAJOR FACTORS OF DEVELOPMENT

Piaget calls on four major factors to help explain development from one set of structures to another. These being firstly, maturation, since this development is a continuation of the embryogenesis; secondly, the role of experience of the physical environment and its effects on the structures of intelligence; thirdly, social transmission in the form of linguistic transmission, education and social interaction; and fourthly, the factor of equilibration or self-regulation.

1.3.1 MATURATION

Piaget, following the 'organic lamp' tradition uses the term "maturation" to refer to a gradually unfolding genetic plan, the genetic influences on development. Maturation thus becomes the development and realisation of

.../potentials

potentials that are of genetic origin. Maturation however, does not explain everything because the average (chronological) ages at which the various stages of development appear tend to vary a great deal from one culture to another. However, the ordering of these stages appears to be constant. Al-Fakhri (1977, p.203) states that;

> "The sequence of stages (Piagetian) revealed in most of the studies is similar all over the world; however, differences have been noted in the onset of each stage in the various cultures."

1.3.2. EXPERIENCE OF OBJECTS

Experience of objects, of the physical reality, is obviously a basic factor in the development of cognitive structures. However, this factor also does not explain everything, as there are some concepts which appear at the beginning of the stage of concrete operations that could not be drawn from experience. For instance, the child attains a notion of substance before either weight or volume. Piaget claims that this conservation of substance could not come from

.../mere

perception, as perception can get at the weight or volume of an object, but cannot give an idea of the amount of substance. Piaget claims that this conservation of substance is simply a matter of logical necessity. Piaget states;

> "He (the child) knows that something is conserved but he does not know what. It is not weight, it is not yet the volume; it is simply a logical form - a logical necessity. There, it seems to me, is an example of a progress in knowledge, a logical necessity for something to be conserved even though no experience can have lead to this notion." (Piaget, 1964. p.179).

Most importantly, Piaget points out that there are two kinds of experience which are psychologically very different, and this is particularly significant from the pedagogical point of view. The first kind of experience is the physical experience of the world - consisting of acting on objects and drawing out knowledge about the objects by abstracting from the objects. The second form of experience Piaget calls logico-mathematical experience, where knowledge

.../is

not drawn from objects, but is drawn from the actions exerted on the objects. Actions transform and modify the object, although the object still remains there. Piaget gives an example of this by showing how one of his children was putting pebbles into various arrangements and counting them, discovering in the end that the number of pebbles remained constant. According to Piaget the child discovered in this instance not a property of the pebbles, but rather a property of the action of ordering - that the sum was independent of the order - and to make a sum an action was necessary; the operation of putting together and counting.

The properties of the actions carried out on objects constituting another form of experience, is to Piaget, the point of departure of mathematical deduction. Piaget does not believe that logic is a derivative of language, but rather a derivative of this logico-mathematical experience. It is a derivative of the total coordination of the subject's actions, actions upon objects of joining, ordering and separating etc. Thus what is needed for the growth of logic is an experience of the actions of the subject, and not an experience of the objects themselves. This experience is of vital necessity before operations can be con-

.../structed.

structed. Furthermore, once the operations have been constructed the experience is no longer needed, and the co-ordination of the actions can take place by themselves via deduction and construction, as occurs with abstract structures.

1.3.3. SOCIAL TRANSMISSION

Although Piaget does not deny the role played by social, linguistic and educational transmission, he does see social transmission of knowledge as only playing a small part in the cognitive development of the individual. To Piaget, the child can only receive valuable information via language or education if he is in a state of development where he can understand that information. In other words, in order to receive information, the child must have already existing a cognitive structure which enables him to assimilate the information. Furthermore, the child must have actively constructed the structure for himself, or the information becomes meaningless. Thus one cannot teach higher mathematics to a five year old child - he does not have the structure that enables him to understand.

Rotman (1977) points out that Piaget sees logic or mathematics as an individual rather than a social creation. In addition, he argues that Piaget claims that his theory of mind is a new 'third way', that sees our mental capacities as neither innate nor the result of social transmission, but as developing in a necessary and logical way, that is the same for all of us. Social cooperation thus becomes no more than the coordination of interpersonal actions - this being made possible by the process of decentering, where the individual achieves objectivity by transcending his own viewpoint. Rotman states that

> "By reducing the contribution society makes to the formation of logic in this way Piaget once more rescues his individualism. But in a slightly modified way, since the conflation of the inter-personal means that the individual has become societised. More importantly, it also means that society has become individualised." (Rotman, 1977, p.166)

1.3.4. EQUILIBRATION

According to Piaget,

.../" ... in

> " ... in the act of knowing, the subject is active, and consequently, faced with an external disturbance, he will react in order to compensate and consequently he will tend towards equilibrium. Equilibrium, defined by active compensation, leads to reversibility." (Piaget, 1964, p.181).

Equilibrium is an active, dynamic process; it is a process of self-regulation - a process that is fundamental to development. Equilibrium regulates development by a progressive compensation of systems. Piaget points out that the process of equilibration takes the form of a succession of levels of equilibrium, of levels that have a sequential probability - there is a sequence of stages or levels and it is not possible to reach the second level unless equilibrium has been achieved at the first level. Each level Piaget determines as being the most probable given that the preceding level has been reached.

Equilibration, then, can be seen as a dynamic process continually moving towards maintaining a steady state of affairs between the interior system of the organism and its external environment. Structures are

.../continually

continually moving towards equilibrium, and once equilibrium is reached the structure becomes more developed, sharper and more clearly delineated than it was previously; thus the activities of the developing individual are continuously directed towards reducing the gaps and inconsistencies within the structure that were never salient previously. However, this very development points out further gaps and inconsistencies which consequently leads to a further need for equilibrium to be realised at a higher level - thus forcing development forward. Equilibrium, although always dynamic, is never absolutely realised. It is the outcome of each progressive stage of development, with the final stage (formal operations) being a relatively equilibrated system of actions. Operational reversibility is a model of an equilibrated system where a transformation in one direction is compensated by a transformation in the other direction.

1.4 THE DEVELOPMENTAL STAGES

It is important to note that Piaget separates the problem of development from the problem of learning. Piaget sees development as a process which concerns the totality of the structure of knowledge, whilst

.../learning

learning is provoked by specific situations. Piaget states;

> "It is (learning), prevoked, in general as opposed to spontaneous. In addition it is a limited process - limited to a single problem or to a single structure." (Piaget, 1964, p.176).

Thus, according to Piaget, development explains learning and learning only occurs as a function of development. Development is not a sum of many learning experiences. Knowledge and cognitive development arise out of the individual interiorising his actions on the world into tightly organised substructures or schemes, in such a manner that the property of the action can be generalised to other contents. These schemes are tightly organised into cognitive structures; there can be interactions between these schemes, i.e. they can assimilate or accommodate each other. The most simple schemes can be seen as reflexes, whilst the later more complex schemes can be seen as transformation rules, plans or strategies. Essentially they form a framework into which incoming information from the environment can be fitted. Thus

.../schemes

schemes are firstly concerned with action on objects, then with the construction of intellectual operations from these actions and consequently with the relationships between these operations. Thus according to Piaget, every thought has resulted from reflective abstractions of actions, and the study of intellectual development is the establishment of the relationships by which new schemes are constructed.

Piaget describes mental development in terms of operations. These operations initially occur, in concrete terms to be followed by symbolic representations as individuals begin to classify and understand objects and events in their environment. Piaget divides mental development into four major periods (stages) that are each related to age.

Phillips (1969) points out that the concept of stages can be useful if three things are borne in mind. These are (1) that different children may pass through the sequence of stages at different rates, (2) that each stage is named for the particular process that has most recently become operative, even though others may occur at the same time in their original form, and (3) that each stage is

.../marked

marked by the formation of a total structure that includes its predecessors within it as necessary sub-structures. Cognition thus advances only by building on and extending all that has already been developed. As development is marked by a striving towards the realisation of equilibrium, so the inability to achieve equilibrium - or the continual experience of disequilibrium marks pathology.

Piaget states that the child moves from one stage to another via the interaction of the four major factors mentioned previously i.e. maturation, experience of physical objects, social transmission and equilibration. Each stage is individually characterised by a specific style of thought, but Piaget does emphasise that it is not so much the stages that are important, but rather all that happens in the transition from one stage to another. There are no 'static' stages, for each stage is the fulfilment of something that was begun in the preceding stage, and is the beginning of something that will lead onto the next stage.

1.4.1 THE SENSORY-MOTOR STAGE (BIRTH-2YRS)

There are obviously many differences between the new-

.../born

born infant and the 2-year-old child, and consequently Piaget divides this period into six substages. The totally dependent, preverbal child becomes by the age of 2, a child who can communicate (albeit understanding far more than what he can say) and who can move around independently. However, these differences are marked by certain similarities, for during this entire period behaviour is dictated by the senses and by motor activity. The child's conception of the world is realised by the perceptions of his senses and by his increasing manipulation and discovery of the objects in his environment. The infant knowing nothing of his own self becomes a 2-year-old aware of a larger external world, and is already beginning to enjoy some control over his world. Piaget claims that in this period, children begin to develop some notion of <u>object permanence.</u>

Infants know only themselves and believe that objects only exist if they are able to see them. Thus "out of sight, out of mind" is a reality in these early months. However, once object permanence is understood the child realises that things exist independently and permanently, in relation to himself; and this marks the beginning of understanding of the larger world.

.../Also

Also important to this stage is the beginning of a conception of causality; the idea that the hand can grasp the bottle and move it towards the mouth etc. Understanding this concept sets the stage for further cognitive development.

1.4.2. THE PREOPERATIONAL STAGE (2 - 7 YEARS)

In this stage the child develops ways of representing objects and events through symbols, including the verbal symbols of language. This then implies that the child can now think about things that are not immediately present to him (in his line of sight), and that he can now begin to solve certain types of problems - particularly those problems based upon visual items. However, the child still continues to be egocentric. The child already realises that the world does not revolve around him, but he is still incapable of stepping outside of himself and adopting another's point of view.

In this stage, classification is a difficult task - as the child tends to reason by one dimension only. In Piaget's famous experiment, children see a bead as either brown or wooden, but not both at once. The

.../child

child is simply unable to classify a single object as two things at once - he is unable to include the class of wooden beads in the class of brown beads.

Piaget also demonstrates that the preoperational child is unable to understand a notion of conservation. Conservation referring to the ability to recognise that the basic attributes of an object such as volume or weight remain the same even when the appearance of an object is transformed. According to Piaget these children are limited by centration - by centering on one dimension of an object to the exclusion of all others. Furthermore they do not understand reversibility; the ability to see transformations in clay for instance, and think back to seeing two lumps of equal size; this being a process of thought that would allow the realisation that the quantity remains the same whatever the shape.

In this period two substages are distinguished:-

Stage 1 (Pre-conceptual Intelligence 2 - 4 yrs):

Here the stage of symbolic or pre-conceptual thought is reached with the appearance of language. The child is able to attach a symbol to an object but is unable

.../to

to construct - by abstractions and generalisations - a concept of the object. In other words, the child cannot distinguish between the general and the particular, for his reasoning is transductive.

Stage 2 (Intuitive Thought 4 - 7 yrs):

In this stage the child appears to have an intuitive grasp of physical and social properties and relationships. However he is still unable to reason logically, as his reasoning still remains linked to his perceptions.

1.4.3. THE CONCRETE OPERATIONAL STAGE (7 - 11 YRS)

At the end of the preoperational stage, the child becomes more flexible in his reasoning, concentrating on more than one dimension at a time, and he begins to conserve. He begins to realise that because something appears to be bigger and longer it is not necessarily so. He cannot however, apply this knowledge to volume and weight until he is older, but once he is able to understand that number remains constant and that mass does not shift, he has entered into concrete operations. Here the child can begin to think logically, although there still exist certain limitations.

.../The

The primary limitation is that the child is just at the beginning of logical thought - a period where he can still only solve problems that are presented in concrete terms; if the problem is to be solved by thought alone, it becomes insoluable.

Once the concrete operational stage is reached, the child is no longer totally egocentric. It is in this stage that the child begins to communicate with others, compare other's points of view with their own, recheck their ideas and decide on what is right. This is, therefore, a stage of cooperation and competition with peers group members, for the social interaction in which ideas are tested.

1.4.4 THE FORMAL OPERATIONAL STAGE (11 - 15 YRS)

In this period the child is generally past the age of relying on concrete objects. Here, he can think about abstractions and visualise logical solutions internally. He is able to apply a single theory to many problems or many theories to a single problem, whereas in concrete operations the child can only attack one problem at a time. In this stage the child is able to organise information, reason

.../scientifically,

scientifically, build up hypotheses through understanding causality, and test these hypotheses, often without manipulating concrete objects.

However, although the adolescent has reached the potential of adult thought he still remains egocentric to an extent. He is able to be logical, but is not necessarily realistic as he generally appears to be absorbed in his new found powers of reason, and tends to look at the world in an idealistic way. As the adolescent moves into adulthood, the quality of the thought structure may not change, but more of a balance between assimilation and accommodation is achieved, and idealism becomes modified and 'softened' by reality.

1.5 PIAGET - PEDAGOGICAL IMPLICATIONS

Piaget has not constructed a theory of teaching, but as he is concerned with cognitive development, he does hold some important implications for pedagogy. Phillips (1969) claims that Piaget's implications lie specifically in three principles; (1) construction through action, (2) transfer as sequential integration of structures, and (3) motivation through

.../cognitive

cognitive conflict.

1.5.1. CONSTRUCTION THROUGH ACTION

To Piaget, knowledge is action - cognition develops from the interiorisation of actions on the world, of operations. The mind is thus not a passive receptacle but an active organising, constructing system. Information from the environment cannot be assimilated unless there are already in existence the relative structures to absorb this information. Piaget points out that knowledge gained via logico-mathematical experience is invented, not merely accepted as is knowledge gained through social transmission. The implication for teaching here, is an emphasis on doing. The child must be allowed to actively discover his world and explore it in such a way that his activity will lead to the development of cognitive structures.

1.5.2 TRANSFER AS SEQUENTIAL INTEGRATION OF STRUCTURES

Structures are not 'given' but are constructed - in the formation of a structure of reasoning each new procedure depends on those the child has just acquired. Once achieved, this structure serves as a starting point for new acquisitions. Consequently no amount

.../of

of 'training' will produce higher levels of thinking. It is at this point that the role of the teacher is questioned - for if Piaget is correct then an individual cannot be 'taught' anything, until he has developed the relative structures enabling assimilation. Thus, the teacher's role becomes not one of imparting knowledge to 'uneducated' children (which Piaget terms learning in the narrow sense, i.e. learning without understanding); but rather one of a facilitator attempting to guide, encourage and facilitate the child to interact with objects in order that he might receive direct feedback from them. For the teacher to be a facilitator would also require sensitive insight into the child's level of cognitive development.

1.5.3. MOTIVATION THROUGH COGNITIVE CONFLICT

Smedslund (1964) argues that logical necessity and internal contradiction are of great importance in the determination of children's intellectual and personal development. Changes in a child's thinking come about not by external reinforcement, but via his efforts to restore equilibrium, resolving a conflict between the information input from the environment and the cognitive structure. Thus, motivation is intrinsic to the

.../activity

activity itself. It follows therefore that, in order to encourage further cognitive development, the 'teacher' (facilitator) attempts to guide the individual in such a way as to induce cognitive conflict by arranging for an optimal discrepancy between the environmental inputs and the existing cognitive structures. Phillips (1969) points out that if the input is precisely congruent with the existing structures, then accommodation would not occur; conversely if the input does not fit the structure at all, then the input is not even partially assimilated. Optimal discrepancy, then, is that where the complexity of the cognitive structure almost, but not fully, matches the complexity of the input. In other words, the individual should have some understanding (but not total understanding) of the information facing him, and he will be self motivated to gain full understanding, simply by the necessity of realising equilibrium. If the information is totally above the individual's comprehension, he will not experience disequilibrium and will not be motivated towards getting to grips with the information.

1.6. ACCELERATION OF COGNITIVE DEVELOPMENT

The idea of accelerating cognitive development has been

.../under

under much debate, with some theorists being in favour of acceleration and others against. Acceleration, in this context, means the effort to move children from the cognitive stage appropriate for their age to a higher stage usually associated with an older age group. Most arguments for acceleration centre around the idea that children show an early 'natural' intellectual curiosity, and this should be encouraged rather than stifled. Arguments against acceleration programmes centre around the idea that although one can accelerate development, conceptual understanding does not necessarily follow, for it is very much an individual experience, and furthermore the emotional development of the young person must be taken into account as any acceleration pressure may cause anxiety.

Piaget's position is that cognitive development, by necessity, much sequentially follow the stage that he has outlined, but he does see acceleration as possible, provided that the structure one wishes to 'facilitate' to the subject can be supported by simpler, more elementary logico-mathematical structures. In this regard Piaget asks us to imagine an analagous structure, but in a simpler, more elementary situation.

.../Piaget,

Piaget, when questioned as to whether or not the developmental stages in children's thinking could be accelerated by practise, training and exercises in perception in memory, pointed out that there are two very different aspects of cognition which must be distinguished; the figurative aspect and the operative aspect.

> "The figurative aspect deals with static configurations. In physical reality there are states, and in addition to these there are transformations which lead from one state to another. In cognitive functioning one has the figurative aspect - for example, perception, imitation, mental imagery etc.
>
> The operative aspect includes operations and the actions which lead from one state to another. In children of the higher stages and in adults, the figurative aspects are subordinated to the operative aspects. Any given state is understood to be the result of some transformation and the point of departure for another transformation." (Piaget, 1964, p.186).

Thus, according to Piaget, exercising perception and memory is 'reinforcing' the figurative aspect without influencing the operative aspect, and this will not accelerate the development of cognitive structures.

> "What needs to be reinforced is the operative aspect - not the analysis of states, but the understanding of transformations".
> (Piaget, 1964, p. 186)

CHAPTER TWO

JAMES RUSSELL'S MODIFICATIONS OF PIAGETIAN THEORY

2. RUSSELL'S MODIFICATIONS OF PIAGET

James Russell (1978), whose book "The Acquisition of Knowledge" has stimulated many of the ideas of this research, offers constructive criticisms of Piaget's genetic epistemology. He compares Baldwin's genetic epistemology to that of Piaget and concludes by offering a theory of cognitive development that attempts to overcome certain limitations existing in Piaget's framework.

2.1 THE ROLE OF SOCIETY & THE CONCEPTUAL SYSTEM

Russell accuses Piaget of attempting to absorb the epistemological into the genetic via his thoroughgoing structuralism, which consequently (in common with empiricists and rationalists) leads Piaget to the implicit assumption that the child acquires knowledge totally by his own efforts without any aid from others. Piaget views social interaction as another form of operational activity and that every process, including the social, is a further manifestation of the universal tendency towards equilibrium.

> "Piaget regards society on the model of the organism, so it is not possible within

.../Piagetian

> Piagetian theory to talk of the cultural transmission of knowledge because this process is itself the working out of an equilibration whose principles transcend and underly social phenomena; 'education' is taken to affect only the ease with which operativity is attained."
> (Russell, 1978, p.209).

Baldwin's approach on the other hand offers an account of the conceptual system within which the child is developing, catering for the dialectic between the child and concrete reality and also the child and the human community. In contrast to Piaget, Baldwin sees the child developing into a ready made (but still evolving) conceptual system.

Thus Baldwin bases his theory on the view that knowledge is essentially 'public property' (a similar view to Wittgenstein). Baldwin claims that the child's awareness of himself must be well established before he is able to appreciate any symbolic meaning, and that it is through language that the child achieves a common syndoxic meaning enabling him to join the cognitive community. This consciousness of self and others

.../develops

develops from social roots (via the important process of imitation) rather than via the cognitive structures being established with the concrete world privately, as Piaget believes.

Essential to Piaget's argument is the view that all individuals tread the same logical path, this being because equilibrium provides a unique but necessary outcome with each stage being the most probable outcome after the previous stage has been equilibrated. By necessity then, all individuals develop identical rules of logic by virtue of their physical interaction with the real world. In the context of Baldwin, Russell takes issue with Piaget's notion of structures being uniquely inevitable and scientific, pointing out that the individual is born into the logic of society - a logic brought about by functional demands.

Baldwin emphasises that a sharing of experiences is a necessary prior condition of objective knowledge. Before the child can think for himself he has to experience with others. This entails the assumption that cognitive development is dependent on the caretaker providing the child with a necessary set of experiences - hence Baldwin's characterization of cognitive

.../development

development as the child's initiation into the conceptual system. The caretaker can be seen as the 'mediator' between society and the infant. Russell points out that in Trevarthen's (1974) observations (where the infant inter alia becomes active, mother vocalises, infant smiles and vocalises) the infant is very basically responding to social signs with other signs, creating and maintaining social interaction. Trevarthen refers to this phenomena as 'primary intersubjectivity' and closely allied to this is the question of imitation.

Russell claims, in support of the Baldwinian dialectic of personal growth, that the infant has an innate ability to share the experiences of others via the process of imitation - prior to the child having any knowledge of the concrete world as separate from himself, he has an awareness of other people being imitable. Imitation is primary, independent of any prior cognitive elaborations, and it is through this process of imitation that the child becomes aware of himself and others as conscious agents; furthermore, it enables a distinction to be made between one's own actions and the actions of others. It is with the onset of imitation that the infant begins to develop a sense of autonomy, realising that his experiences can be shared with others. Thus

.../the

the child begins to develop some primitive knowledge of the minds of others, whilst at the same time he is beginning to actively explore his physical world; acquiring a knowledge of the regularities in the concrete world.

Russell claims that the child brings these two kinds of knowledge to the process of language acquisition. Furthermore, achieving competence in the use of the categories and structures of the language system has a dual effect on the child's cognitive development. The child's cognitions become structured by the categories and structures of language and secondly, the child develops towards a public mode of consciousness.

> "At the outset, this public consciousness is relatively unstructured by the conventions of the conceptual system. The child is, however, aware of the shared nature of conceptual knowledge, and thus has some notion of the criteria for true judgements, corresponding roughly to Baldwin's syndoxic commonness..... When the child does acquire knowledge, not so much of what the rules are but of their objective 'transpersonal' nature,

.../we

> we have the kind of understanding which Baldwin seemed to be intending by synnomic judgement. Eventually he is able to reflect on the system itself and evolve a consciousness of what he has been doing all along - 'inference' in Baldwin's terminology."
> (Russell, 1978, p.229)

Russell warns against viewing this imitation from a 'social determinist' framework as this ascribes a certain passive nature to the child - it should rather be seen as a process of initiation into the conceptual system where the child is actively participating as opposed to merely copying the system's characteristics. The child is actively involved in dynamic interaction with others in the community.

Piaget does not overlook the importance of social interaction entirely, seeing it as a 'motivating force' that moves the child towards overcoming his egocentrism - the interaction with peers provides the child with alternative, conflicting perspectives. Thus to Piaget, knowledge develops not from others directly, but from the efforts of the child to reconcile these conflicting

.../perspectives

perspectives with his own towards the eventual realisation of the 'epistemic', or objective self.

Considering the role of society in cognitive development necessarily leads towards a notion of cultural variability in the way a child comes to grasp concrete truths. The Baldwinian approach (in contrast to Piaget) would appear to be more adequate here, suggesting that there are various possible routes that can be taken in the developmental process from the sensorimotor stage to the preoperational stage for instance; that the actual route taken is the conceptual system that the child is being cognitively initiated into.

It follows then that where in cross-cultural research, for example, the individuals of a specific culture are found to be predominantly preoperational in their conceptual development, this is no reflection of the cognitive potential of the individuals, but rather an expression of the functional demands on the conceptual systems. Any further distance travelled in conceptual development is irrelevant to the lives of the individuals within the culture.

This consideration in no way refutes the validity of

../Piaget's

Piaget's theory or his outline of the developmental stages, but if anything broadens it. However what must be realised is that Piaget's theory of cognitive development is essentially an account of the development of scientific knowledge, and the way in which scientific laws of the real world are understood. Because there may be subtle alternative routes that a child may follow in the development from sensorimotor actions to the preoperational stage for instance, in no way implies that the child may move from the sensorimotor stage directly to concrete operations. Piaget's sequence of the developmental stages still holds true.

De Lemos (1969) has demonstrated this precisely in a study of the development of conservation in Aboriginal children. It was found that the three stages of development described by Piaget could clearly be distinguished, and the explanations and responses given by the children revealed the same processes of development that Piaget outlines for European (Genevan) children. However, whilst the general results supported Piaget's stages of development, the invariant order of development for the conservation of quantity and weight as postulated by Piaget was not supported. De Lemos found that more children succeeded on the test of weight rather

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than that of quantity. Furthermore, contrary to Piaget's postulation, the conservation of area was not achieved at the same age as the conservation of quantity and length, but was a much later achievement.

Dasen (1975) compared concrete operational development across three cultures. In the light of a model of ecological functionalism the hypothesis that nomadic, hunting, subsistence-economy populations would develop spatial concepts more rapidly than would sedentary, agriculturalists groups was supported. This finding is of significance to Piaget's theory in that it demonstrates that the rates of development are not uniform across cultures. In other words the "structure d'ensenmble" that Piaget posits for the Genevan child does not always hold in different cultures. Dasen correctly points out that what has become apparent from this type of cross-cultural research is that it is not possible to look at the processes that organise thinking within a culture, without taking cogniscence of the value that the culture places on various concepts.

Where then, one may ask, does Piaget's observations of Genevan children prove to be of major significance? It is the author's opinion that the outline of the

.../conceptual

conceptual development of Genevan children can be seen as an 'ideal type' (in the Weberian sense), to be used as a form of measuring stick, against which the researcher can attempt to analyse the development of scientific thought in other cultures. With the emphasis on Genevan children being 'ideal', the fact that they may be more 'advanced' than individuals of another culture does not necessarily imply that they are 'better'. As Dasen (1977) points out, one should rather look at cultures in terms of being different, than as being deficient which implies that individuals of various cultures are different but equal, insofar as there exists the potential towards conceptual development. Furthermore, a value system need not be associated with a stage theory.

> "Indeed, the differences we do find beyond the basic universals are the reflection of a truly valuable cultural plurality."
> (Dasen, 1977, p.12)

Considering social influences brings into focus the debates concerning the effects of differing child-rearing practises, both cross-culturally and within cultures, on conceptual development. Chiv Lian-Hwang

.../(1972)

(1972) provides evidence demonstrating the individual differences in cognitive style are closely related to different family experiences. Bing (1963) shows more directly that discrepant verbal ability is fostered by a close relationship with a somewhat intrusive mother, whilst discrepant non-verbal abilities are enhanced by allowing the child a considerable degree of freedom to experiment on his own.

However, the striking contrasts in conceptual development cannot be accounted for by differences in child-rearing practises and differences in the conceptual systems alone, but also needs consideration of what Russell terms 'functional interests'.

2.2. A VIEW OF NECESSITY

Within the context of the influence of the conceptual system, Russell objects to the way in which Piaget's cognitive structuralism attributes an 'asocial' necessity to mental structures. Piaget claims that equilibrium (autoregulation) is a necessity, and furthermore that the development of thought follows, by necessity, one single path.

> "Perhaps the most fundamental point of

.../divergence

> divergence between the Piagetian and the present account is that we are concerned with the fact that conceptual intelligence relies on the acquisition of the criteria for the truth of judgements, and these criteria are, of necessity, socially constructed. A mental structure may be equilibrated or otherwise but it cannot be true or false."
> (Russell, 1978, p.238)

Russell supports the Wittgensteinian notion that knowledge is a system of consensual judgements; furthermore public agreement is only made possible by the use of language, and by putting language to use in the world a system of necessity is evolved.

> "We have had to 'impose' the particular system of verbal concepts on ourselves in order that we might communicate and have any social existence at all."
> (Russell, 1978, p.241)

Thus to Russell, necessity lies in the network of rule-bound concepts that enable us to communicate about

.../various

various abstractions from the concrete reality; it is the system of rule-bound concepts that necessitates the structuring of thought. More specifically, it would appear that Russell's criticism of necessity is only directed towards Piaget's assumption that each progressive stage realised in cognitive development, via convergent reconstruction, is necessarily inevitable. In other words, logico-mathematical thought, for instance, is the inevitable and necessary outcome of the equilibration and convergent reconstruction of concrete operations. To Russell, logico-mathematical thought necessarily arises out of our system of rule-bound concepts that enable communication, and also from our need to communicate.

Russell's criticism, however, does not appear to challenge Piaget's assumption that equilibrium is a cognitive necessity - that equilibrium must be reached before there can be any further development in mental structures.

2.3. TOWARDS CONSCIOUSNESS

Russell also objects to the way in which Piaget's cognitive structuralism regards consciousness. Russell

.../claims

claims that cognitive structuralism disposes of knowledge as something ineluctably conscious by supplementing it with non-consious structures.

> "Thus Piaget denies the relevance of consciousness because 'operational behaviour' makes it redundant; and although he claims that the child reflects on structures as he gets towards the formal stage his view is clearly that mental machinery determines the acquisition of knowledge:"
> (Russell, 1978, p.243)

Rotman (1977) points this out more clearly by asking how does a subject know which encounters with his environment are disequilibrating? In Piaget's framework, the subject cannot know experientially, neither can he decide by making a rational judgement, for equilibration is the very source of rationality and intelligence. Piaget cannot invoke an external agency to mediate the working of the equilibrium principle as it is equilibrium itself which performs this function.

> "Piaget's solution to the problem is a

.../radical

> radical one. He eliminates the subject's role entirely, replacing him by the automatic working of his cognitive system, and concludes that a subject neither knows nor judges an encounter with the world to be disequilibrating. His cognitive system simply experiences, and responds appropriately to, disequilibria much as a gyroscope might to being tilted or, to be more appropriately physiological, the statocyst in our ear does when we move from the vertical."
> (Rotman, 1977, p.100)

Thus, on the one hand, Piaget is proposing a purely mechanical nature of equilibrium and self-regulation - thus removing from psychological investigation all the difficulties associated with a conscious purposive agent and on the other hand, Piaget perceives each process of growth - the physical growth from embryo to child, cognitive growth from child to adult and epistemic subject - as governed by increasing equilibrium. Thus it would appear that Piaget's 'tertium quid' is collapsing into an inatist or preformatist account even if each developmental stage becomes the most <u>probable</u> after the occurence of the preceding one.

.../Russell

Russell claims that it is only by making reference to consciousness, that the acquisition of knowledge can be made intelligible. Furthermore, the rejection of consciousness in behaviourism, cognitive structuralism and many other ranges of scientific psychology springs from a philosophical naiveté on the part of psychologists.

Following Wittgenstein's line of thought, it can be argued that if an individual is to be considered as being able to make cognitive judgements, then consciousness becomes a necessary condition. In addition, in any judgemental process there has to exist a public criterion against which the judgement can be made. As public criteria-bound evidence is a necessity, it can be said that agreement about objective criteria is ingrained within the conceptual system. Paradoxically, Wittgenstein argues that consciousness is not a private enterprise but a public possession, rooted in the conceptual system.

Russell therefore claims that knowledge is not merely something that happens to the child (via a mechanical process of equilibrium); rather there is a necessary and determining conscious element. Knowledge can only be made public and objective by the use of

.../language

language, a symbolic system, and the child is only able to make his world objective to himself by using the rules of this linguistic-conceptual system. The development and realisation of knowledge is thus necessarily a function of consciousness or awareness.

> ".....consciousness comes in by virtue of the fact that the child 'knows he knows' indeed knows how he knows and can thus say in principle - if not always in practise - why he is judging the way he is; and thus we re-encounter Kant's principle of reflexive self-awareness, and the justification of judgements as truths by objective criteria."
> (Russell, 1978, p.250)

Following from the argument of consciousness, Russell introduces a notion of intentionality - as knowledge does not merely happen to an individual, the evolving ability to make judgements must be seen as involving the purposive utilization of what the subject already knows, in order that he may accommodate that which he does not know. Furthermore, there must exist some conscious intention towards becoming aware of public

.../criteria

criteria against which judgements are made. Russell points out that because there is intentional purposive action, does not imply that the subject is conscious of what is happening to his mental processes.

> "So although the mental processes are not always conscious, the act of thinking is necessarily conscious in the sense that what we think is a function of what we intend, which is a function of what we want - and hence the interrelationship of consciousness, knowledge and functional interests ....."
> (Russell, 1978, p.253)

2.3.1. A COGNITIVE UNCONSCIOUS

Being confronted with the notion that mental processes are not always conscious, Russell finds it useful to propose the existence of a 'Cognitive Unconscious' similar to the Freudian notion of the unconscious. Russell points out that Piaget's structuralism points towards non-conscious thought structures; because of their formal complexity, they never become conscious and never need to become conscious. Freud, on the other hand, did not regard unconscious mental processes

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in this way. In Freud's model, unconscious material can become conscious under certain conditions by virtue of the fact that unconscious material is initially conscious.

Russell proposes that a cognitive unconscious develops as a direct result of the growth of conscious mental processes; that all thinking carried out unconsciously can in principle be realised consciously.

> "At the outset the child's consciousness consists of sensory data, and what will later be the unconscious and conscious elements of thinking are fused. But as thinking becomes more determined by things and more structured by abstract features of the conceptual system (for example, grammar, logic), as one element of thinking becomes more public, in Baldwin's sense, and thus conscious, there is a corresponding, inverse development towards a purely private, unmediated kind of thinking which splits away from the determination by the data and forms moulding what is essentially public in consciousness.

.../...consciousness

> ...consciousness is, in one sense, a public phenomenon, the cognitive unconscious is private insofar as it lacks everything that thought requires to be knowledge - especially it lacks any sensory content, linguistic expression, all that Baldwin meant by systems of 'control' and the reflexive self-consciousness which must accompany this."
> (Russell, 1978, p.254)

Russell speculates that the cognitive unconscious functions in a seemingly automatic, ballistic and autonomous manner in relation to conscious thought, because it lacks the reflective self-consciousness that is associated with objective knowledge. Russell claims that conscious thought engages the unconscious by setting it problems; the cognitive unconscious has the ability to solve problems and provide creative insights because it is free to make unusual associations and groupings of data that would not be possible in conscious thought, as it is not tied down by a rule bound context. The data of the cognitive unconscious is able to be processed only because it was initially conscious. Furthermore, the way in which the data is

.../organised

organised is dependent upon how it is originally consciously experienced. Russell shows that the relationship between the cognitive unconscious and the conscious mind is dialectical as the conscious mind engages the unconscious processes and the unconscious processes influence what will be consciously judged.

Introducing the concept of the cognitive unconscious is heuristically valuable, in that it enables consideration to be given to a dialectic between the affective life and cognition; biological invariants and cognition, whilst at the same time catering for Piaget's assumption that the structures or transformations forming the foundations of cognition can never be made conscious. Although the structures are manufactured out of conscious operations upon the real world, all that the subject is cognitively conscious of at any point in time is the content of the structures - the raw data and the physical manifestations of these cognitive structures, which Piaget describes as schemes.

Considering individual consciousness and conceptual development as being rooted in the conceptual system, however, smacks of social determinism, leading towards

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a destruction of the argument that the child is active as opposed to passive in the process of cognitive development, unless consideration is given to what Russell terms 'functional interests.'

2.4. FUNCTIONAL INTERESTS

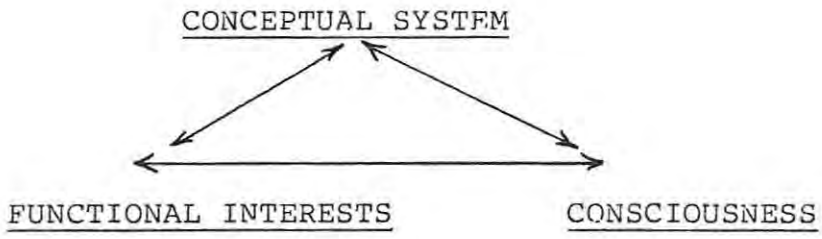
Functional interests can be seen as being what the child wants to do and takes pleasure in doing from one instance to another.

> "Of course these functional interests develop: from the infant shaking his rattle; the toddler building a tower of bricks; the adolescent taking a radio apart to see how it works. When these are given free rein or when they appear to serve no practical or educational end the adult calls these 'play'."
> (Russell, 1978, p.240)

It is this concept of functional interests that brings a certain voluntarism into Russell's account of conceptual development. It gives the child a freedom to 'discover' and explore areas of the world that he is interested in, and consequently allows for an explana-

.../tion

tion of individual differences existing in cognitive development both cross-culturally and within any one culture. However, this freedom is not to be seen as absolute, for functional interests also find their roots within the conceptual system. Russell thus proposes a dialectical interrelationship which exists between the conceptual system, consciousness and functional interests (diagramatically illustrated below).



Moving in a clockwise direction, the conceptual system determines the child's consciousness (particularly via the vehicle of language); the level of conscious knowledge then determines the kinds of functional interests that the child will entertain. The functional interests then influence the way in which the child will put the conceptual system to use. Functional interests also influence the way in which the conceptual system is manifested to the child. The process may also function in the reverse in that the child's level of consciousness determines the degree to which he is

.../capable

capable of construing the conceptual system as it is manifested to him by others. The structure of the conceptual system will determine how the manifestation of the child's functional interests will be entertained by others, and finally the functional interests determine the things that the child wishes to be conscious of at any particular time.

> "Indeed, another way of conceiving functional interests is as that which determines the forms of life the child expresses and wishes to pursue at any particular stage in his development, or second in time. Needless to say, there is a phylogenetic component in these interests which diminishes throughout the course of the acquisition of knowledge."
>
> (Russell, 1978, p.245)

Russell does not deny that human thought is structured, but prefers to see the rules of thought (being isomorphic to Piaget's structures of concrete operations) as existing <u>outside</u> the individual and within the conceptual system. These rules of thought evolved within the

.../culture

culture in response to expedite functional demands; the system is moulded out of a practical necessity. Thus according to Russell, in cognitive development, the child is initiated into this system via the 'bridge' of rule-bound concepts through the intersubjective experiences of everyday social interaction - the child is continually building onto his stock of cognitive concepts within the framework of a set of functional interests. As mentioned previously, the infant has the ability to enjoy intersubjective experiences with the caretaker, and it is through this intersubjectivity that the caretaker guides the infant initially, towards the rule-bound concepts, and hence towards the development of cognitive structures and consequently, functional interests. Thus the child co-ordinates his rule-bound concepts by the continuous process of restructuring concepts out of lower elements into a system which is already there. Thinking, eventually, becomes more autonomous as it becomes progressively independent of its functional origins.

To be considered alongside with functional interests, is the role of motivation in cognitive development.

2.5. MOTIVATION

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According to Piaget, it is the principle of equilibration that energises cognitive growth since biological invariants of survival and adaptation create a need for the subject to achieve equilibrium, thus necessarily providing the motivation towards cognitive growth so that achieving equilibrium is a logical necessity. Russell points out that the equilibrium principle points to the fact that for any cognitive changes to occur, there must initially exist a certain conflict or inconsistency in the mind of the subject - the subject must be able to recognise the inconsistency that exists before he can move towards achieving equilibrium. However, Russell asks why the recognition of an inconsistency on the part of the subject should necessarily motivate cognitive change, unless the subject himself actually wants to overcome the inconsistency? In other words, Russell is allowing consideration for certain inconsistencies that the individual might accept without necessarily moving towards equilibration (a similar notion is to be found in Riegel's theory of dialectical operations.)

To Russell, the explanation as to why in certain instances a subject may be content to agree or disagree with others holding different judgements is to be found

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in the nature of the conceptual system.

> "On the present perspective, the fact that some kinds of judgement have to attain consistency, but not others, is in the nature of the system of concrete knowledge which is being transmitted to the child; and thus the attainment of consistency between truth values of such transformational and multi-relational judgements is a form of life to which the child has to adapt...equilibrium is a principle which reflects the norms of our thinking, which in turn, we might add, reflect forms of life rather than biological necessities of autoregulation. The motivational aspect of this is what might be called the 'cultural education' of the child's interests in the direction of certain kinds of consistency."
> (Russell, 1978, p.265)

In order for the child to be able to recognise any inconsistency or conflict, he must be aware of how the

.../conceptual

conceptual system construes the relevant rule-bound concept - the child must be exposed to certain standards of consistency and, furthermore, his functional interests must be such that the child wants to achieve consistency in the relevant rule-bound concept. Russell thus claims that the social life of the subject initially creates and then directs his interests towards achieving various standards of consistency, viewing Piaget's assimilation-accommodation model as redundant, and replacing it with an interest-accommodation model.

Russell claims that Piaget's Assimilation Principle can be viewed as a motivational principle - what is assimilated is what the subject wants to do and what he is interested in doing. Where the subject wants to do something but fails in doing it points toward a failure in the subject's accommodatory capacity. The subject's interests are not matched to his accommodatory capacity, to what his cognitive structures can handle. In support of Baldwin, Russell views the human infant as enjoying an 'accommodatory plasticity', and, dependent on what the infant wants to do, determines the direction his accommodatory capacity will take. Thus Russell's interest-accommodation model appears to include, transcend and thus broaden Piaget's assimilation-

.../accommodation

accommodation model.

> "Thus we have an interest-accommodation model and a dialectic similar to that of Baldwin in which cognitive growth is generated by schematic, semblant, experimental, imitative, selective interests, the conceptual heirs of which are the functional aspect of language use, judgemental proposition, abstraction, intension, accretion of meanings and synthesis. The dialectical nature of the system ensures that the motivational aspect evolves with every accommodatory success so there is a mutual determination between what the child wants and what he can do or understand."
> (Russell, 1978, p.267)

As the child at the end of the sensorimotor stage becomes aware of the self-world dicotomy, he may have developed a reflexive awareness of his own interests and is able to differentiate between wanting a thing and the act of attaining it - a realisation that the action is not an inevitable consequence of the action.

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Thus, Russell claims that behaviour has a certain autonomy over interests an idea which is fundamental to any consideration of moral development in the child. There exists an intimate relationship between motivation and moral judgement, and it is Baldwin who proposes that moral development and ideas of value and worth originate in the earliest selective interests of the infant (guided via the intersubjective experience of the caretaker.)

Consequently, Russell points out that with the autonomy of behaviour over interests, the freedom exists for a subject simultaneously to follow his interests whilst being able to condemn them morally.

CHAPTER THREE

RUSSELL'S IMPLICATIONS TO CROSS-CULTURAL RESEARCH AND THE PRESENT RESEARCH

3.1 CROSS-CULTURAL PIAGETIAN RESEARCH:

Russell's propositions do not invalidate Piaget's theory of cognitive development as there is no denial that cognitive development takes place in a manner as outlined by Piaget. What Russell does attempt, if anything, is to take a closer, analytical view of various problematical areas within the Piagetian framework and to offer a deeper, more adequate explanation of those areas that appear to have been 'glossed' over. He also provides a modified and extended theory that can help lead to a fuller, more exhaustive explanation of cognitive development. The heart of this research lies at the cross-cultural interface, and it would appear that a consideration of Russell's propositions allows for a better interpretation of cross-cultural research findings and, more importantly, a deeper insight into the cross-cultural interface than the 'unmodified' Piagetian framework would permit.

Dasen (1977) points out that one of the major critisms of Piaget's theory of development in cross-cultural research is that his notion of development is really the development of a Western scientist. There would appear to be a certain ethnocentric bias in Piaget; furthermore the demonstration that all individuals

.../reason

reason according to a certain structure does not necessarily maintain that this is their preferred mode of reasoning. Berry (1974) for example, points out that we might not be adequately sampling the culturally relevant skills Piagetian theory may be asking: "how well can they do our tricks?", whereas what should be asked is "how well can they do their tricks?". In this light 'primitive' thought may not be primitive at all, but sophisticated. What this points to, is that a possibility exists that the reason this mode of thought (in non-industrialised societies) has been labelled inferior is because we are unable to understand it.

There are many instances where evidence of a sophisticated non-Western type of thinking have been found in cultures, much of which cannot be understood by the Western scientist. For instance, the logic of acupuncture, or the sophisticated navigatory techniques of Trukese islanders as portrayed by Thomas Gladwin (1973) - a method of accurate navigation totally alien from western methods. The point made here is that these other areas, where a 'different' kind of thinking is required, may in fact be the kind of thinking that is most valued in a particular culture.

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However, Dasen (1977) still finds enough evidence to support Piaget's universalistic hypotheses in cross-cultural research, which demonstrates that in all cultures there is the existence and potential for the scientific thought that Piaget characterises.

> "I maintain this universalistic hypothesis in spite of recent suggestions of an ethnocentric bias in Piaget's theory. On the other hand, I willingly concede that there are alternative cognitive structures that may be more adaptive to a given environment and more culturally valued."
> (Dasen, 1977, p.10)

This appears to lend credibility to Russell's considerations of the conceptual system of a society, and the functional demands upon that system being reflected respectively in the cognitive structures and functional interests of the individuals of a particular culture.

However, although cultural differences are found in the way basic cognitive processes combine into functional cognitive systems, it appears that cross-cultural research has revealed that we are unlikely to find

.../cultural

cultural differences in the basic components of cognitive processes. That is, in support of Piaget, individuals of all cultures are engaged in the development of cognition through their actions on the real world - these actions are attached to a real physical world having a certain structure, and must therefore lead to experiences which are culturally universal in their basic form.

Opper (1977), in a study with Thai urban and rural children, demonstrates that intellectual development does not depend upon a specific type of object with which the individual must interact. Rather, what is required is an environment containing a variety of objects, with which the internal processes can interact. Furthermore, environments with a variety of objects are generally a universal feature which points toward the apparent universality of certain types of cognitive operations. Opper demonstrates that although the objects in the environments of rural and urban Thai children are different - with respect to mass media, toys, home ammenities, transport and so forth - there is nevertheless a similarity in the processes of cognitive development because of the diversity of objects that exist in the environments of the two groups (To

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be noted also is that both groups of Thai children share the same conceptual system).

Dasen (1977) points out that the qualitative aspects of Piaget's theory (i.e. the sequence of stages, the structural properties and the types of explanations given by children) have been verified by the majority of cross-cultural research. Furthermore, the horizontal décalages (i.e. the sequential conservations of quantity, weight, volume,) have been verified to a significant extent, on the average, within a population but has not been verified within each individual. Finally, considerable cultural variation has been found in the quantitative aspects of Piaget's theory (i.e. the rate of development through the stages). It is to be noted that Russell does not wish to overstate the case of the influence of the conceptual system in cognitive development. From research findings it can be accepted that Piaget's universality hinges upon the interaction with a diverse environment and not specific objects as Opper points out - it is the transformations that are particularly important and not the objects themselves. However, Russell's notion of the conceptual system must be seen as 'colouring' cognitive development differently from

.../culture

culture to culture.

Not only does cross-cultural research lend credibility to Russell's proposals of the role of the conceptual system, but also to his notions of functional interests and their dialectical origin from the functional demands on the conceptual system.

> "The most influential type of experience (in the development of mass, weight and volume amongst Kamba children) may be found among those activities within a culture that are useful and vital for survival."
> (Kiminyo, 1977, p.65)

Obviously these functional demands vary from culture to culture, and Laurendeau-Bendavid (1977) points out that the variations or décalage in conceptual development, found cross-culturally, usually exist in a predictable direction - the greater the extent of education, industrialization or urbanisation in a culture, the faster is the rate of conceptual development. For example, Laurendeau-Bendavid, in a study of Canadian and Rwanda children, with respect to cultural

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and educational variations states:

> "In sum, school attendance appears to be a facilitating rather than a necessary condition for the attainment of concrete operations and objective causal representations, since some of the children without any schooling do attain these. On the other hand school attendance is a necessary but not sufficient condition for the attainment of formal operations, since only subjects with full school experience, - and only a few of these - were found to have reached this level",
> (Laurendeau-Bendavid, 1977, p.165)

and H W Page, in a study of Zulu youths states:

> "For rural youths, simply getting older did not guarantee the acquisition of more sophisticated concepts of space. Attending school, however, did provide an advantage, although this was not proportional to the amount of schooling."
> (Page, 1973, p.15)

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In yet another study, Lepper (1967) concludes that the development of Piagetian conservation concepts reflects differences in cultural backgrounds rather than in race.

> "This study showed that there were differences in the development of the science-related concepts in negro and white first-graders. These differences, according to the interpretation presented in this study, can be accounted for by differences in the subjects' backgrounds. This study did not reflect any innate differences in the subjects." (Lepper, 1967, p. 337)

Much of Piagetian cross-cultural research, like those mentioned, points toward the significant influences of cultural backgrounds, educational transmission and environmental demands, in attempting to explain the observed cross-cultural décalages existing in conceptual development. These findings support the credibility of Russell's model, although Russell goes even deeper than the conceptual system and functional demands in his notion of functional interests and motivation. Thus, not only are Russell's theoretical propositions of considerable utility to any form of Piagetian analysis,

.../they

they also are extremely functional in that applying Russell to the findings of Piagetian cross-cultural research results in a more exhaustive and adequate interpretation.

Piagetian theory revolves around four major factors as being responsible for cognitive growth. These are:

a) Biological factors - these are linked to the 'epigenetic system' and offer an account of the interactions that exist between the genotype and the physical environment during the growth.

b) Equilibration factors - this offers an account of development as a function of multiple activities; of actions upon the environment. Actions are co-ordinated into organised systems, which are dependent upon the environment as well as on epigenetic potentialities. Intelligence is seen as being the highest level of systematic organisation in the march towards adaptation and autoregulation.

.../c) Social

c) Social factors and interpersonal co-ordination - this offers an account of the constant and valuable interpersonal exchange that occurs throughout the developmental process, pointing towards the social life of the subject amongst peers and elders, towards the realisation of objective judgement and the 'epistemic' self.

d) Educational and cultural transmission - this offers an account of the role (albeit with Piaget, a relatively minor one) that traditions and education play in conceptual development.

Piaget is rather vague, if not unconvincing, in the emphasis he places on the factors (c) and (d). It is here specifically that Russell's propositions gain significant utility for an exhaustive theory of cognitive development and it is the author's opinion that any analysis of cognitive development within a Piagetian framework is incomplete without the incorporation of Russell's proposals.

3.2 RUSSELL'S PEDAGOGICAL IMPLICATIONS

.../Russell's

Russell's pedagogical implications can be seen as building on the foundationary implications offered by Piaget. Russell points towards a necessary consideration of the activity of the child himself, to realise a pedagogy that will significantly transform the subject. The idea of functional interests implies a voluntary or freedom-of-choice nature being allowed to the subject and which must be inherent in the design of any educational programme. Furthermore, Russell's concern with the conceptual system points towards an awareness of the concepts valued/central to the conceptual system in which the child is being cognitively socialised into. More importantly, any educational programme must be tailored towards the meeting of individual needs - making use of the individual's functional interests to create motivation.

Many of Piaget's and Russell's implications coincide with the principles underlying the 'progressive' or open education movement. The major principles of this school are (a) a celebration of individuality and the belief that such individuality thrives best where it is least fettered, and (b) the belief that pupils know best what they want to learn and learn best what they want to know.

.../This

This progressive 'child centered' approach sees knowledge as action, resulting from the child 'doing'. It emphasises the need to develop the child's potentials via activity on the part of the child himself, rather than forcing adult techniques and ideas on the child by treating him as a passive empty object that needs to be filled with knowledge. Thus, the emphasis here, as in Russell, is in freedom of choice, giving functional interests rein.

The primary role of education can be seen as preparing the individual to cope adequately with the world, giving him adequate strategies of survival; the ability to cope and adapt to a rapidly changing world in a creative and flexible manner. The 'progressive' educationalists claim that contemporary education is not achieving this. The knowledge explosion which is causing much change so rapidly in industrial societies, prevents one from being able to say much about the nature and demands of contemporary society in twenty or thirty years hence,by the time a pupil is 25 years old most of the mathematics, grammar, history, economics inter alia which he learnt at school will be out of date. The emphasis of any pedagogy should be thus on cognitive development - the development of cognitive structures, rather than filling

.../a

a subject's head with learnt facts (which Carl Rogers, like Piaget, calls 'learning in the narrow sense'). Postman and Weingartener (1969) point out that the best that can be said of an ex-pupil, taking for granted that he is able to remember most of what he is taught, is that he is a walking encyclopedia of outdated information.

The significance of Piaget and Russell lies in their challenge to contemporary education. Postman and Weingartener (1971) point out some frightening things that children are possibly learning in contemporary schools today:

a) that passive acceptance is a better response to ideas than any active criticism;

b) that discovering knowledge is beyond the power of the individual students (it comes from the teacher!);

c) that recall is the highest form of intellectual development;

.../d) that

d) that the voice of authority is to be trusted and more valued than independent judgement (obey the principle now and the prime minister will be obeyed later!);

e) that feelings are irrelevant to education;

f) that there is always a single right answer to a question;

g) that english is not history, and history is not mathematics, that sciences are major subjects whilst art and music are minor subjects. That a subject is something that you 'take' and when you've taken it then you have 'had it'. If you've had it, then you are immune and need not take it again - what Carl Rogers calls the "vaccination theory of education".

Carl Rogers, being a member of the progressive school, points out that the aims of an educational programme are:

1) to show a person how to learn, how to teach

.../himself;

himself;

2) to reduce alienation through an understanding of technology;

3) to produce a fully functioning person;

4) to produce a person who has a social conscience and who is an active member of society.

Rogers, in looking at learning, claims that humans have a natural potentiality for learning, and that significant learning takes place when the subject-matter is relevant to the individual. Much of what is learnt is acquired through doing - through action - and any learning which involves a change in the perception of oneself is threatening and tends to be resisted. Learning is facilitated when the subject participates responsibly in the learning process, i.e. when learning is self-initiated and self-evaluated. Furthermore, the most socially useful learning in the modern world is learning of the process of learning; a continual openess of experience and incorporation into oneself of the process of change.

.../Although,

Although, as mentioned earlier, Piaget distinguishes between cognitive development and the process of learning much of what Rogers has said can be realised in Piagetian theory of cognitive development, specifically in its implications to pedagogy. Where the 'progressive' movement appears to have fallen down, in a Piagetian point of view, is in looking at learning as the basic unit of analysis, whereas it should transcend this to look at cognitive development and mental structures.

> "Consequently our hypothesis is that the so-called aptitudes of "good" students in mathematics or physics etc., consist above all in their being able to adapt to the type of instruction offered them, whereas students who are "bad" in these fields, but successful in others, are actually able to master the problems they appear not to understand - on condition that they approach them by another route.
>
> What they do not understand are the "lessons" and not the subject".
> (Piaget, 1973, p.14)

.../Many

Many methods used in teaching today are psychologically archaic insofar as they rest on merely factors such as the simple transmission of knowledge; teachers, ideally, should attempt to grasp the "natural" psychogenetic development of the logico-mathematical operations involved in cognitive development with specific reference to the subject matter being taught.

> "..., experiments that we have been able to carry out on the development of mathematical and physical ideas have demonstrated that one of the basic causes of passivity in children in such fields, instead of the free development of intellectual activity they should provide, is due to the insufficient dissociation that is maintained between questions of logic and numerical or metric questions. In a problem of velocities, for example, the student must simultaneously manage reasoning concerning the distances covered and the lengths utilised, and carry out a computation with the numbers that express these quantities. While the logical structure of the problem is not solidly assured, the numerical considerations

.../remain

> remain without meaning, and on the contrary, they obscure the system of relationships between each element.... This is again an example of the error risked by believing in the innate logic of the child, whereas logic is built up step by step through his activities".
> (Piaget, 1973, p.99)

Blocking the reasoning powers of the pupil can thus occur in many varied ways. What is required then to obtain the fullest satisfaction is a closer association between pedagogical analysis and psychological analysis.

Cognitive development, as seen with Russell's modifications, is tied intimately to functional interests. A person develops cognitively in areas that are relevant and interesting to him - the subject is in a sense choosing areas in which he will cognitively develop. As the subject develops and discovers the world via action, the role of the teacher comes under fire. Holt (1976) being also a member of the progressive school, views that contemporary educational systems are characterised by coercion - that the functions of the contemporary school are to, firstly

.../shut

shut children out of the adult world; and
secondly,
to rank them as winners and losers via the process of labelling and streaming.

The school creates winners and losers to fill positions that society requires. The school also has to persuade the losers (provide the rationale) that their state of affairs is necessary and that the school's way of picking winners and losers is just and fair, that the losers in fact deserve to lose.

In opposition to this, Holt claims the teacher should have a role of facilitator/guide and should attempt to assist the child in furthering his/her inquiry into the world - the child is encouraged towards self-discovery by asking his own questions and then answering them. Children are thus viewed by the progressive educationalists as being very curious, resourceful, energetic and capable explorers of the world around them. The contemporary school is seen as destroying the individual's creativity and ability to learn, and consequently muffling the process of cognitive development by making pupils afraid of not doing what other people want, of not pleasing, of making mistakes, of failing and of being wrong.

.../It

It is interesting to note that A S Neill of Summerhill fame, a psychologist influenced by Freud, also held many similar views to the progressive educationalist movement. It is obvious that much of what progressive educationalists propose for pedagogy is supported by Piaget's and Russell's theory of cognitive development. The most important point that Piaget offers for an educational programme is a criterion of success - it is not in the ability to memorise numerous facts, or to perform in a certain way, but rather to develop cognitively - to develop cognitive structures necessary for psychological and emotional stability that enable the individual to cope creatively with ever changing social conditions and forces of living. However, a critisism to be levelled at the progressive educationalists is that they remain at the micro-level of analysis and fail to consider the wider role of social institutions as existing in a dialectical relationship with the educational institution. At this point, Russell's proposals of the conceptual system become important.

3.3 AIMS OF THE PRESENT RESEARCH

The aim of this research is to attempt the development of a programme that will facilitate change in conceptual development, promoting intellectual growth, via the

.../vehicle

vehicle of Piagetian theory. Piaget advances the view that intellectual growth takes place through the everyday transactions that the individual enjoys with the physical and social environments. The aim of this programme can be seen as a psychological therapeutic process - in the clinical sense this is always directed towards the restoration of the individual to normal everyday transactions with people and society; a process of placing the individual in a position where he can avail himself of the normal and beneficial growth processes.

It is felt that certain peoples, because of various historical and physical incidents, find themselves outside of the mainstream transactions that lead to technological intellectual growth as it is usefully employed in industrial, technological societies. The programme of development can be seen as being a psychological therapeutic process in that the aim is to place the individual (who finds it difficult to cope with industrial or scientific concepts) into the mainstream of transactions in order that he/she may be able to, through a certain 'self-help' process facilitated or encouraged by the therapeutic programme, advance conceptually towards an understanding of Western techno-

.../logical

logical/scientific thought. Obviously the programme focuses on the cross-cultural interface and the closing of the gap in scientific conceptual development between industrialized and non-industrialized societies - emphasising a purely voluntary participation on the part of the subjects. In other words, the programme will be used by those who are not content with their level of conceptual development and wish to experience cognitive advancement.

It is proposed that to put an individual into the mainstream of transactions requires Piagetian theory and an understanding of Russell's proposals - particularly a consideration of what he terms functional interests, which will focus the individual's consciousness of those elements and areas that would otherwise be ignored. This process will be achieved by adhering strictly to Piaget, thus enabling a diagnosis of where the individual is in terms of the level of his conceptual development (i.e. pre-operational, concrete operations inter alia). This will entail the analysis of scientific concepts to attempt to find a profile of conceptual development. This profile will be matched with expected levels of subjects in advantaged Western technological societies performance/development. It

.../is

is important to note that such a facilitatory programme is not aimed at accelerating the cognitive development of individuals such that they may realise formal reasoning at an earlier age or a quicker rate than Piaget outlines. It is specifically aimed at those who can be viewed as 'stage retarded' or behind the levels of development as outlined by Piaget, bearing in mind that Piaget's outline is viewed as ideal.

The development of such a programme necessitates the consideration of three specific aims. These are:

1) The development of a body of theory that can assist towards the therapeutic intervention and the facilitation of cognitive growth;

2) The realisation of a diagnostic battery that is useful to provide insight into the individual's level of conceptual development and problematical areas, and to indicate how the programme is to be tailored to individual needs;

3) To provide a precedure of intervention

.../whereby

whereby the facilitation of conceptual advancement can take place.

Let us look at these three specific areas in more detail.

3.4 THE DEVELOPMENT OF A BODY OF THEORY

The need to look at Russell stems from the fact that Piaget underestimates the degree to which circumstances can alter the rate of conceptual development. Furthermore, it has already been realised that Piaget is not adequate in his catering of consciousness nor the conceptual system, seeing cognitive development as an inevitable necessary process without any role given to the awareness and functional interests of the individual.

It is proposed, having considered Russell, that a notion of functional interests is particularly important to any programme considering cognitive development. These functional interests are what the individual wants and is interested in doing. Thus it follows that in a programme such as this, if the programme can make full use of functional interests then, by necessity of the nature of the individual's cognitive system, the indivi-

.../dual

dual will be motivated towards realisation of the goals of the programme - this being conceptual growth. More importantly, the functional interests mark the most important areas with which the programme should start operating. It is in this sense then that the therapeutic intervention is particularly "individually centered" in that it looks specifically at the functional interests of each individual using them towards intellectual growth in the individual.

The author proposes that functional interests provide us with the only adequate vehicle through which we can 'break into' the individual's cognitive system in a creative manner. If, as Piaget proposes, equilibration of mental structures remains a function of totally non-conscious mechanical functioning of mental machinery, then proposing a developmental programme such as this would boil down to a hit-and-miss affair - there would be no way of knowing concisely in which conceptual area the programme should begin, nor is there any guarantee that the subject's motivation is being constructively utilised. As mentioned previously, Piaget eliminates the role of the subject (apart from his acting on the world). Consequently, it may be possible that this is a salient reason for facilitatory programmes of cogni-

.../tive

tive growth, operating on a purely Piagetian model, realizing that although it is possible to advance cognition from one level to another, training only results in what is termed specific transfer.

Specific transfer implies that where in a facilitatory programme, an individual is trained in a specific concept, the advancement that occurs remains limited to that particular concept - there is no general advancement in other conceptual areas, which would be the case in non-specific tranfer. Lawson & Wollman (1976) in an attempt to encourage a transition from concrete operations to formal cognitive functioning, found that instruction with a Piagetian design (i.e. concentrating on the realisation of transformations) can affect the transition from concrete to formal cognitive functioning and that experimental groups performed significantly better than control groups on specific transfer tasks, but results were not significant in non-specific transfer. This implies that although the training was effective in promoting formal thought with regard to one aspect of formal reasoning, it was limited in extent.

The aim of this research is to realise a programme that

.../will

will facilitate non-specific transfer in cognitive growth, and it is proposed that this can be realised by catering for individual functional interests in the therapeutic programme, and by capitalising on them in a particular way.

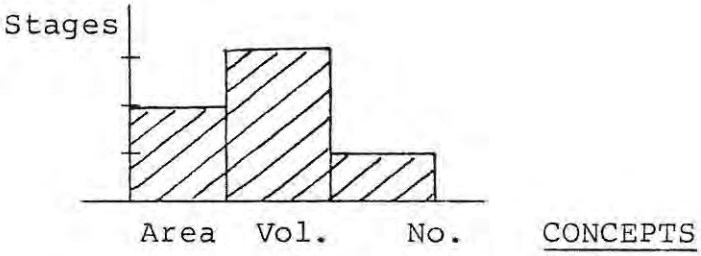
The next question is how can we use these functional interests? It is proposed that whilst employing Piaget's levels of cognitive development to diagnose where the individual lies in cognitive growth, i.e. at pre-operational, concrete or formal operations, these levels can be broken down further so as to reflect the individual's functional interests by analysing various scientific concepts. Thus, what is intended is the development of a histogram (profile of conceptual development) reflecting the differing stages of development as outlined by Piaget.

If, for example, an analysis is being made of the individual's profile in the conservation of area, volume and number, the individual is given Piagetian tasks to discover the stage of development he is at within each concept. Thus it may be found that the individual being predominantly at a pre-operational level is more advanced in the conservation of volume than area. A

.../profile

profile is built up detailing the cognitive development of the individual, looking in a simplified form, something like the following:

Figure 1



In the light of Russel's justification of functional interests, it is proposed that those concepts in which the individual is found to be most advanced (i.e. the modal areas of the histogram) are in fact the reflections of the individual's functional interests within his cognitive system.

Having discovered the areas in which functional interests lie, the programme of intervention is then able to proceed by focussing on the advancement of conceptual development in these areas of functional interests, in an attempt to reach what can be termed a critical point, where the individual, in order to continue advancing in the specific conceptual area of interest must begin to develop his cognition in other related conceptual areas which is the remainder of his profile. Thus 'critical

.../points'

points' imply instances at which Piaget's notion of horizontal dècalage comes into being. It is proposed that in this manner of advancing functional interests to a critical point thus inducing horizontal dècalage, non-specific transfer will be achieved. Furthermore, once the individual has equilibrated his cognitive structures by the process of accommodation allowing advancement in the other conceptual areas, the programme can continue the cycle inducing the individual to advance in the new area of functional interests in such a manner that the process is repeated. The aim is to encourage convergent reconstruction of cognitive structures by the individual towards the next level of cognitive operations and cognitive growth.

3.5 THE REALISATION OF A DIAGNOSTIC BATTERY

Piaget provides numerous tasks for a comprehensive range of scientific concepts that can be employed in a diagnostic battery and in the procedure of inducing cognitive growth. However, the diagnostic battery cannot be compiled of random, non-related scientific concepts. Let us recall that Piaget sees the facilitation of cognitive growth as being possible provided that the structure one wishes to facilitate can be supported by more elementary logico-mathematical

.../structures.

structures. The implication of this for any facilitatory programme is that one should work within a specific scientific concept that can be reduced to simpler conceptual elements. By reducing to simpler concepts it becomes possible to work with pre-operational reasoning, whilst the actual concept may require formal reasoning. This allows a programme to use a specific complex concept and work anywhere from pre-operational reasoning. The present research will be working specifically with the concept of force, as it lends itself adequately to the inclusion of simpler concepts whilst at the same time is a formal reasoning concept. Furthermore, once the individual is able to understand the concept of force (mechanics), he is thereafter on the road toward being able to get to grips with more complex concepts such as heat (energy), light-waves, electricity and the like.

Let us analyse how force is reduced to its component concepts:

a) Force = Mass x Acceleration

b) Acceleration = $\frac{\text{Velocity}}{\text{Time}}$ or $\frac{\text{Distance}}{\text{Time}^2}$

c) Velocity = $\frac{\text{Distance}}{\text{Time}}$

d) Distance requires a relative understanding of the concept of length

.../e) Length

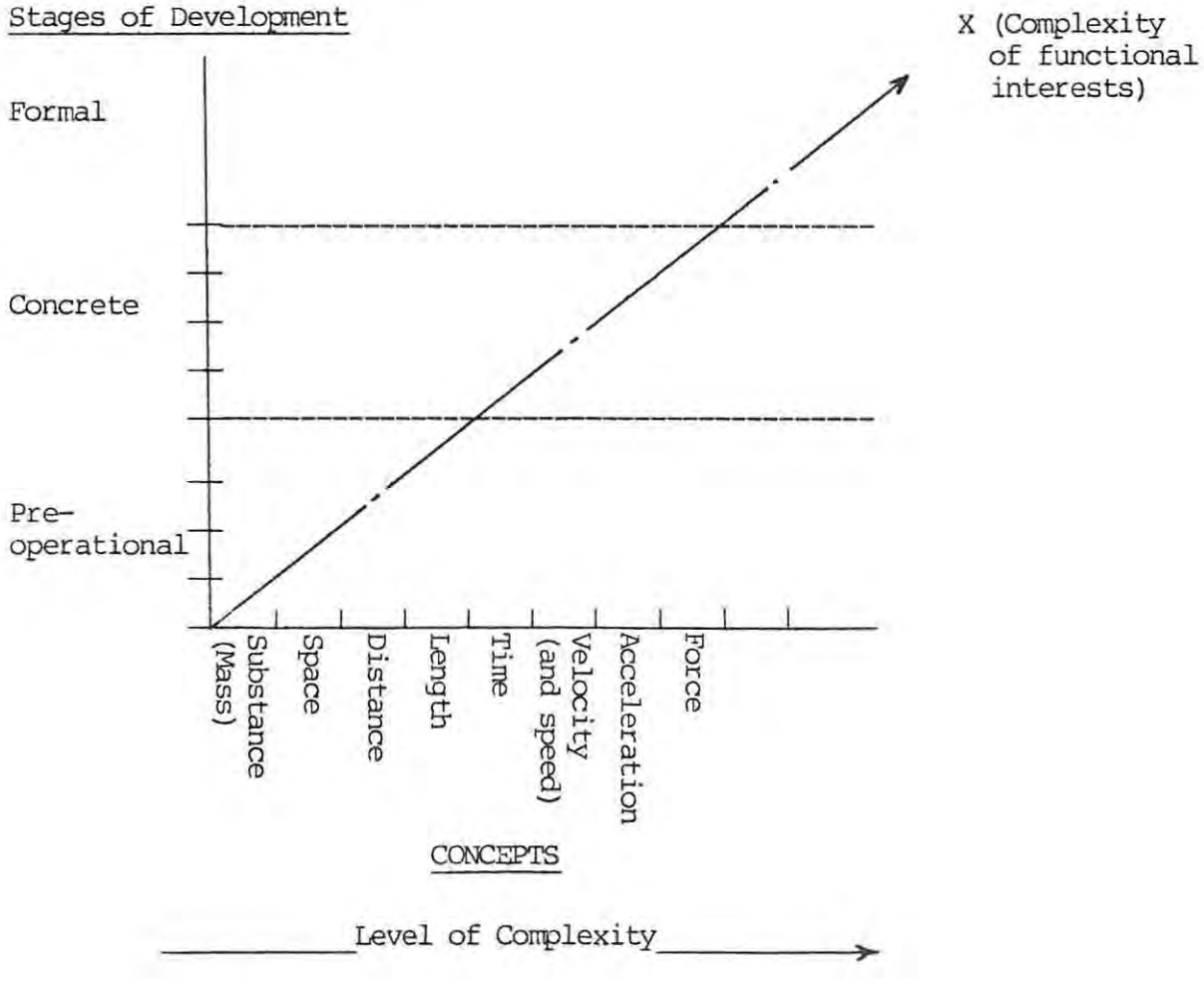
e) Length requires a relative understanding of the concept of space

f) Space requires a relative understanding of the concept of mass

g) Mass requires the conservation of weight and of substance - which Piaget views as being intuitive to a certain extent at the pre-operational level.

The profile of conceptual development in a programme designed towards the facilitation of cognitive growth, using the concept of force will look as follows:

Figure 2 - PROFILE OF CONCEPTUAL DEVELOPMENT



The line (X) represents the degree of 'complexity of functional interests' and stems from Russell's "interest-accommodation" model where he points out that functional interests develop in complexity, isomorphic to the accommodation of more complex structures. In other words, the child is interested in that of which he has some understanding. Thus as the individual progresses in cognitive growth towards the comprehension of more complex concepts, so his functional interests will progress. Theoretically then, if a point is taken on line 'X' of the conceptual profile, the subject should have a substantial accommodation of concepts to the left of that point, but not of those to the right of that point.

Functional interests are continually changing with the process of growth which implies that in the process of the facilitation programme, when the 'critical point' is reached in following functional interests and the individual develops on other conceptual areas, functional interests will also change and the programme must then cater for and exploit these new interests. Understanding the concept of force requires formal reasoning, thus a pre-operational individual could not be expected to have functional interests in the properties of force,

.../but

but he will be interested in space and length. The programme is simply using these interests in the more elementary areas to facilitate cognitive growth and interests in more advanced areas, which, in turn can then be used to facilitate further cognitive growth. The distance that instruction must go within the area of any particular concept remains inherent in the concept itself, as will be seen when a closer look is taken at Piaget's analysis of the concepts that will be used in this therapeutic programme.

3.6. A PROCEDURE OF THERAPEUTIC INTERVENTION

Piagetian theory provides an adequate procedure of intervention, when combined with the use of the proposed diagnostic battery that will allow the development of a conceptual profile of the individual. There are three major guidelines that can be deduced from Piaget when considering his pedagogical implications:

> "First, provide a child with learning opportunities that are commensurate with his level of cognitive development. Commensurate activities may be defined as activities that are far enough in advance of a person's present level of functioning to be motivating

.../but

but not so much in advance that they will be frustrating. Because tempos of development vary from person to person, individual appraisal of a person's current level of functioning is necessary to determine the individually appropriate level for reasoning activities. Second, after a student is provided with cognitively appropriate activities, he must then do the interacting - you can't do it for him.... In addition the teacher provides questions that challenge reason and thought, questions that motivates a person to explore and to thrust a bit further.... Third, for a teacher to assume the role just described he or she must be trained in Piaget's theory of cognitive development; that is the teacher must know how development proceeds and what characterises a child's past, present and succeeding levels of cognitive functioning. The teacher also must have knowledge of the reasoning assessments used by the Geneva group and be skilled in providing opportunities for the pupil to apply reasoning to

.../ongoing

ongoing problem situations".
(B. Stephens, 1977, p.139)

It is interesting to note that the evolution of the science curriculum over the past 50 years is characterised by three major stages (Appel, 1977). The first stage can be seen as being fact-centred, characterised by text books and teacher/lecture demonstration methods. The second stage has a process-structure focus, with the influence of Piaget resulting in the "inquiry" and "discovery" methods. The third stage (which Appel claims we are just beginning to enter) is individualised in terms of instruction and interdisciplinery in terms of science content. The goal that has emerged for stage three science teaching is termed "scientific literacy", which can be seen as the ability to look at a situation from a scientific point of view or as a functional understanding of natural phenomena. Thus, realisation of the goal of scientific literacy also implies the realisation of cognitive development.

"It is not possible to be scientifically literate...at the level of pre-operational thought, or even at the level of concrete operations. In order to understand

.../natural

> natural phenomenon to the degree where judgements can be made concerning the proposed actions of the scientific community, or of the legislature, one should be functioning at the level of formal operations. Thus not only has Piaget provided us with a basis for choosing science content and the sequence of it, but also from his theory has evolved another long range goal; encouraging the development of formal operational thought".
> (Appel, 1977, p.190)

Appel thus points towards a stage III science programme termed the "Personalised Approach to Science Education" (PASE). This programme is individualised by the following procedure:

a) Children are placed in a programme at a level consistent with their own levels of cognitive development;

b) Children progress at their own rates of speed;

.../c) Children

c) Children are evaluated individually by means of problem centred activities that they choose to complete;

d) Children choose the lessons they wish to do;

e) Children keep track of their own progress.

(Appel, 1977, p.193)

The envisaged therapeutic programme of this research includes and transcends all that Appel focuses on in the PASE approach, for the instruction procedure would follow the PASE programme very closely in that it clearly exploits Piaget's pedagogical implications. However, it would transcend PASE, not only individualising the procedure of instruction by catering for individual needs and interests, but also attempting to provide a conceptual profile that allows for an immediate diagnosis of individual needs and functional interests.

The proposed therapeutic programme remains strictly Piagetian in its use of a battery of Piagetian tasks (in this case, those tasks that are related to the conceptual elements of the concept of force). The

.../tasks

tasks are built into a battery, applied, observed and measured in the method that Piaget describes, being administered to the subject by beginning with the most simple (i.e. substance) working forwards to the most complex (i.e. force) so that a profile of conceptual development of the subject can be realised. Once the profile has been realised, the area of instruction is decided upon and intermediate goals set. Piagetian tasks relevant to the area of instruction are employed for content matter. The method of instruction would be similar to PASE principles, concentrating on the active participation of the subject, with the role of the instructor being that a facilitator, guiding the subject towards the discovery of transformations. The instruction pattern would particularly follow Smedslund's (1964) implications of creating cognitive conflict in the subject to induce cognitive reorganisation- but in the particular area of the functional interests of the individual. By working in the areas of functional interests the individual should, in theory, entertain a certain self-motivation towards participating in the procedure and the achievement of cognitive growth.

The goals of such a procedure can be outlined as follows:

.../1) to

1) to facilitate cognitive development and 'scientific literacy';

2) to develop the ability to use and apply theoretical models;

3) to develop the individual's analytic ability;

4) to motivate the individual towards action, trying out ideas, making decisions and the realisation of self management, self motivation and self confidence.

3.7. A CONSIDERATION OF LANGUAGE

Any programme intending to operate at the cross-cultural interface must give consideration to the role of language. Piaget allocates a minor role to language in cognitive development and although this research modifies Piaget's point of view by considering the importance of the conceptual system, the consideration given to language here remains closely allied to Piaget's theory. Piaget sees the individual's logic as being constructed by the individual, and not as the result of any transmission through language. In other words

.../Piaget's

Piaget's view is that one cannot understand the meaning of a word unless one has already constructed the necessary structures that would allow one to procure meaning from a word.

The view held in this research is that there does exist a 'social logic' which is to be found in the conceptual system. However, this cannot simply be adopted by the individual - he must construct and discover it for himself - there is, so to speak, a discovering of something that is already there. The conceptual system then can be seen as functioning almost as a guide and verifier of what the individual discovers and constructs as logic and knowledge.

The language used in the testing situation is kept at a very simplistic level (as can be seen by the types of questions asked in the tasks - c.f. forthcoming descriptions of tasks, chapter 4), using words that young and mature subjects can cope with. All questions are open ended in that they allow the subject, whatever his linguistic capabilities, to explain as best he can what he thinks to be the case.

In this light it is felt that even though the research

.../concerns

concerns itself with the cross-cultural interface there should be no serious language barriers, as long as there is adequate interpretation. Ideally the experimenter/facilitator should be fluent in the language of the cultural group that he is dealing with. In this research a skilled interpreter will be employed to interpret precisely what the experimenter says, and what the subject says.

CHAPTER FOUR

THE EXPERIMENT

INTRODUCTION

The present study does not attempt an empirical analysis of the diagnostic battery but takes the form of a pilot study exploring whether the diagnostic battery does, in fact, reveal a useful conceptual profile unique to each individual, and what character the profile takes on.

Subjects were not chosen at random, but on their availability to be tested. A total of twentyfour subjects were tested - 12 whites (6 males and 6 females) and 12 blacks (6 males and 6 females) - with the aim of trying to achieve conceptual profiles that could be broadly classified into three areas, these being;

a) profiles revealing evidence of formal thinking

b) profiles revealing evidence of predominantly concrete operations,

c) profiles revealing evidence of predominantly pre-operational thinking.

.../In

In order to achieve profiles in these three areas, the first subjects tested in either racial group were of mature ages (in terms of scientific literacy), working backwards towards subjects of younger ages. Thus white subjects ranged between the ages of 6 years and 26 years old, and black subjects between the ages of 15 years and 54 years old. The black subjects tested were considerably older than the white subjects as Grahamstown can be considered to be essentially rural, lacking an extensive industrial or technological environment.

The testing procedure for each task followed the method and design outlined explicitly by Piaget in his descriptions of the tasks and the types of questions put to subjects.

After the subjects had been tested on all of the tasks, they were asked which of the tasks in the battery they found the most interesting, which tasks they found the least interesting, which tasks they liked, and which tasks they disliked, in an attempt to see of their responses related to the characteristics of their conceptual profiles in terms of the proposed theory of the relationship of functional interests.

.../All

All interviews were recorded on tape and then transposed into a conceptual profile. A skilled interpreter was used for all interviews with black subjects.

4.1 CONSERVATION OF SUBSTANCE

Piaget points out that the conservation of substance is a necessary prerequisite to the conservation of qualities such as volume and weight. How then does a child conserve a substance well in advance of its attributes? This is only possible by virtue that the child initially views substance as an undifferentiated and global quality. Thus conservation of substance represents the simplest possible quantification of qualities which distinguishes it sharply from the measurement of more complex and differentiated qualities such as weight and volume.

Substance is quantified before its attributes because it provides the child with an undifferentiated quality, from which the child can then advance to the special qualities that become quantified in the very course of their differentiation. As opposed to object permanence, where the problem of conservation is to establish the invariance of shape or size, the conservation of substance requires the grasp of the invariance of the support of that which makes up the substance of the object. When an object is changed into different shapes and dimensions the permanence of its substance can only

.../be

be grasped through neutralising these different qualities (i.e. shapes and dimensions). This process requires the division of the object into homogeneous parts. In this way substance becomes a quantum as soon as the substantial quality is considered invariable. The conservation of substance can be seen as presupposing an implicit adoption of atomism.

Briefly then, the conservation of substance marks both the beginning of the quantification of qualities and the completion of the construction of objects. Piaget outlines four major stages in the development of the conservation of substance, weight and volume.

4.1.2 METHOD

The subject is handed a ball of plasticine, together with a lump of the same material. He is then asked to make another ball 'as big and as heavy' to the ball he was given. Once the subject is satisfied that the two balls are identical, the demonstrator changes the shape of one of them by rolling it into a coil shape, sausage shape, by flattening it into a disc, or by cutting it up into pieces. The demonstrator then asks the subject if the two objects still have the same quantity of matter, weight and volume etc. The subject

.../is

is expected to justify his answers to enable determination, not only whether he accepts the idea of conservation, but also how he substantiates it.

4.1.3. STAGES OF DEVELOPMENT

STAGE 1 - The absence of conservation

This stage reflects a total failure to grasp the conservation of substance, weight and volume even with very slight deformations in shape. In this stage subjects are convinced that the quantity of matter increases or decreases with all changes in shape. They appear to have no criterion for deciding in favour of increases rather than decreases. The choice varies from one subject to another. The subject's answer depends on whether he focuses attention on the differences in thickness, length or diameter, etc.

Stage 1 subjects are not yet in full possession of quantifying operations and thus fail to grasp the conservation of matter. When subjects in this stage justify an increase or decrease in the quantity of matter, they confine themselves to invoking just one of the relations in question - i.e. "it is longer", "thicker", or "flatter", etc., and they completely ignore

.../other

other relations. They do not realise that the differences cancel out once they are co-ordinated into a total system. Furthermore, they are uncertain as to whether the distorted ball can be restored to its original state, and when they are, they view this process in purely empirical terms and not in terms of rational reversibility.

STAGE II - Towards the conservation of substance

Stage II sees the discovery of the conservation of substance, but not of weight and volume. Sub-stage IIA is characterised by reactions that oscillate between those characteristic of stage I and those of Sub-stage IIB, where the conservation of substance is invoked immediately as a logical necessity.

SUB-STAGE IIA - Intermediate reactions between non-conservation and the conservation of substance

This stage reflects the problems of conservation - there exists a conflict between direct experience or perception and rational operations. If the subjects of this stage rely on perceptions alone they tend to argue like subjects of the previous stage. As soon as they stop relying on appearance and reflect on the transfor-

.../mations

mations they are forcibly lead towards the conservation of matter. In this stage they tend to vascillate between reliance on perception and transformations. Piaget points out that the two operations that lead them there are identification and reversibility. Identification refers to the idea that 'nothing has been taken away or added' to the transformed ball. Identification alone cannot lead to conservation, but only when reversibility enters the scene (i.e. direct and inverse operations - operational thinking). With true reversibility, the return to the starting point appears to the subject as a logical necessity, and not merely as an empirical possibility. Reversibility means that the subject has grasped that the operations that were responsible for the transformations are reversible.

SUB-STAGE IIB - The conservation of substance

In contrast to sub-stage IIA, the operational mechanism overrides perceptive intuition, and the conservation of matter is acknowledged under all circumstances - unlike the conservation of weight and volume which only occur later. In other words, at this stage, although the distorted ball is seen as containing the same amount of plasticine and can be restored to its original shape,

.../subjects

subjects tend to argue that the distorted ball is of an increased or decreased weight or volume.

SUB-STAGE IIIA - Intermediate reactions between non-conservation and conservation of weight

Again here can be distinguished an intermediate group who deny the conservation of weight from those who affirm it a priori as a logical necessity. Vascillation in this stage can be demonstrated as follows - "the plasticine sausage is heavier because a little extra has been put in (i.e. the sausage has been elongated), but it does not weigh any more because nothing has been added". Thus true reversibility has not been grasped, and the invariance of weight is not discovered. The subject experiences conflict between his grasp of the conservation of substance and his perceptive intuitions, as related to the quantification of weight.

SUB-STAGE IIIB - The conservation of weight and of substance but not of volume

In this stage, weight becomes divorced from the perceptive intuition of the object (subjective), to the object itself. In other words the quantification of weight is

.../fused

fused with the conservation of substance - the invariance of weight is conceived as a logical necessity.

Stage IV (IVA and IVB) deals with the conservation of volume and will not be discussed here, as it is not directly related to the concept of force and thus is not included in the diagnostic battery.

4.2. CONSERVATION OF SPACE

Piaget makes a distinction between perceived space and conceived space. Perceptual recognition of spatial relationships begins in the sensorimotor phase. Initially topological relationships are perceived and eventually with the recognition of object permanence and constancies of size and shape, the child comes to recognise projective and euclidean spatial relationships.

Only discussed here, for the diagnostic battery, are euclidean spatial relationships as they are more complex than topological or projective spatial relationships. The euclidean concept of space rests on the concepts of parallels, angles, proportions and the conservation of distance and measurement. Euclidean space is thus a vast network which embraces all objects and merely consists of relations of order being applied simultaneously to all three dimensions. Within this network, each object is linked with others in three directions (left-right, above-below, and before-behind), along parallel lines of one dimension whilst intersecting the other two dimensions at right-angles. In other words, objects are located into a three-dimensional reference system of vertical and horizontal co-ordi-

.../nates.

nates. This reference frame is not simply composed of relations of order between various objects, but also applies to the positions the objects occupy, which enables the relations between objects to be maintained as invariant despite any potential displacement of the objects. Piaget points out that this frame of reference constituting euclidean space can be likened to a 'container' which is relatively independent of the mobile objects that are 'contained' within it.

4.2.2. METHOD - THE HORIZONTAL AND VERTICAL AXES

The simplest reference frame of the physical world is provided in the horizontal and vertical axes. The task here is then to compel the subject to make reference to these natural axes in order that his conceptual reference frame can be investigated.

Concept of the Horizontal

The subject is shown a frame housing two identical bottles that can be tilted to any degree around a central point. One bottle is half filled with a coloured liquid. The other bottle contains a piece of card - representing the liquid in the alternate bottle - identical in colour and amount to the liquid.

.../The

The card can be revolved around a central point such that it can parallel any angle of the level of liquid with relation to how the bottle is tilted.

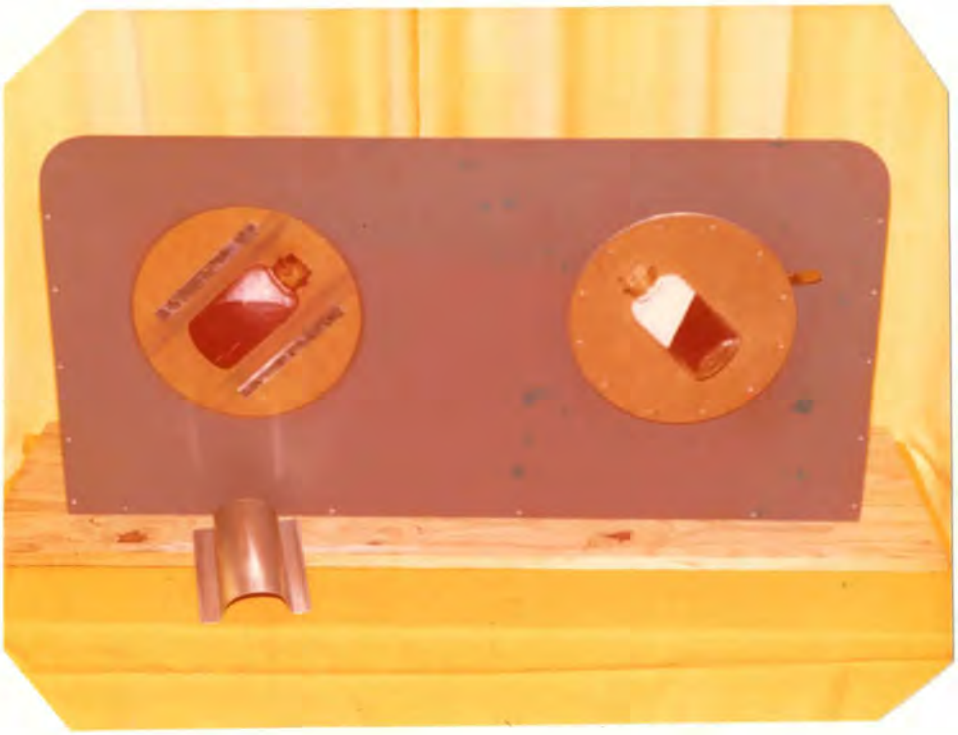
The subject is initially shown both bottles and how to manoeuvre the coloured card in the second bottle. Care is taken to make the subject realise that the coloured card represents the liquid in the other bottle. The experimenter covers the liquid so that the subject is unable to see it, and tilts both bottles in the same direction to equivalent angles. The subject is then asked to move the coloured card in the alternate bottle to show the new position of the liquid. The bottle containing the liquid is then uncovered, and the level of the card is compared with it.

The experimenter can then tilt the bottle containing the liquid to various angles in full view of the subject, and then handing the subject a set of outline drawings of the bottle that correspond to the positions that the bottle was tilted to, asking the subject to draw the position of the level of the liquid in each diagram. Care is taken to ensure that each diagram illustrates a line, representing the edge of the table in such a way that this horizontal, directly perceived, can assist

..../in

in judging the position of the liquid.

Figure 3 - The frame and bottles



Concept of the Vertical

The subject is shown a mountain of plasticine and asked to plant posts 'nice and straight' on the summit, on the ground nearby, and on the slopes of the mountain. It is important to make clear to the subject what is meant by 'straight' and 'sloping'. The subject is also asked to draw the mountain, showing the posts either 'nice and straight' or sloping. The subject may also be asked to draw houses and trees on the

.../mountain.

mountain.

4.2.3. STAGES OF DEVELOPMENT

STAGE I - Inability to distinguish surface or planes, in the case of either fluids or solids

In this stage subjects are unable to distinguish planes as such. They think of the fluid in the bottle in purely topological terms - as merely something inside the bottle - and not according to euclidean concepts such as straight lines, planes, inclinations or dimensions. Thus fluid levels are not shown in a line or as a plane figure, but as a blot or closed figure inside the bottle regardless of its true position. With the posts on the mountain, subjects tend to draw them lying on the mountain, in proximity with the slope. Some lie flat along the slope whilst others are placed in random fashion inside the outline of the mountain. Houses are attached to the mountain slope by their side walls; whatever their mode of arrangement, objects are never placed vertical.

The reactions of this stage indicate a total absence of horizontal-vertical co-ordinates, which is due initially to a total disregard for orientation of

.../objects,

objects, because as yet there exists no relations applying to empty space.

SUB-STAGE IIA - Water level shown parallel with the base of bottle and trees perpendicular to the mountain side

When the subject learns to abstract the surface of the liquid as a plane and locate the posts to the mountain-side, he still fails to grasp the orientation of the fluid in a titled bottle or the posts to an inclined slope. He thinks of the fluid as moving towards the neck of the bottle, not by displacement, but because it is expanding and increasing in volume; it is because of this increase that the fluid draws nearer the neck as the bottle is tipped, while the surface remains parallel to the base. Subjects of this stage do not notice that the level remains horizontal. Furthermore, these subjects are only slightly influenced by the outcome of the experiment when it is performed before them; they constantly assert that the level remains parallel to the base of the bottle. However, subjects of this stage are beginning to use straight lines and planes under certain conditions. Trees and posts are drawn perpendicular to the slope; the concept of right-angles begins to emerge as a suppliment to the concepts of the

.../plane

plane and the parallel.

SUB-STAGE IIB - Intermediate types of response

This stage marks responses midway between those of stage IIA and the gradual discovery of the horizontal and the vertical. Here the subject begins to indicate the direction the liquid will move when the bottle is tilted. They can shift the liquid from its position parallel to the base of the bottle, so that the liquid-line is no longer rigidly linked to the tilt of the bottle. As they still do not have a system of reference to base their picture of the liquid when it is no longer parallel to the base of the bottle, nor how to determine the angle between the level of the liquid and the sides of the bottle, they attempt to relate the liquid to the corners of the vessel. Only when the bottle is completely inverted is there correct judgement, since the liquid is once again parallel to the base. The concept of the horizontal is still beyond subjects of this stage owing to their inability to use references external to the bottle.

With the concept of the vertical, subjects tend to place posts and trees vertical on the mountain, but in their drawings still show them as either perpendicular to the

.../slope

slope or somewhere between the perpendicular and the vertical. In other words the vertical is reproduced in some situations and not in others because in each different situation he bases his judgement on a different system of reference without realising it. Thus, at this stage, the concept of the vertical is not conceived in operational terms, but is merely intuitive, being governed by the perceptual context.

STAGE III - The discovery of the vertical and horizontal

At this stage the subject gradually begins to make use of reference systems, constructing co-ordinate axes which embrace the entire spatial field. There esists an intermediate stage between stage IIB and stage IIIA, where the subject discovers the horizontal when the bottle is lying on its side, together with partial discovery of the vertical. This indicates a widening of the limited system of reference with which the subject was previously satisfied. With the discovery of the horizontal the level of the liquid is no longer drawn parallel with the base, or joined to one corner.

SUB-STAGE IIIA

This stage is marked by the trial and error constructions

.../of

of vertical and horizontal axes. Subjects are able to recognise the horizontal and the vertical but only succeed in making this elementary comparison upon repeated attempts - often after reproducing the same errors as those seen in stage II. Thus the concepts of horizontal and vertical are not constructed at the beginning of stage III but during the actual course of this stage; i.e. not until these operations have been tightly organised into a system.

SUB-STAGE IIIB

This stage sees the subject making use of references from parts of the object; the construction of the horizontal and vertical is formulated in operational terms and is applied directly to all situations.

4.3. CONSERVATION OF DISTANCE

Piaget points out that the concepts of distance and length are psychologically two quite different situations. Consequently they must be analysed separately. Distance, in Piagetian terms, refers to the linear separation of objects - to empty space - whilst length refers to linear size of objects such as the size of sticks or the paths along which one walks. Logically these concepts are interdependent, as distance can be seen as the length of an interval or empty space between objects, and length is the distance taken up by the object. Piaget asks whether children recognise this interdependence at the outset of development, and if not, how they come to its realisation. Developing notions of distance enables the child to pass from the elementary topological relations of space to the more complex euclidean relations.

Piaget views the reconstruction of distance as a problem that is separate from both perceptual estimates and measurement; it is a condition of measurement in itself. Distance is not isotropic to perceptual space in that it represents a deduction that follows from knowledge of the order of points and an understanding of the intervals between the points in relation to the order

.../of

of points.

4.3.2. METHOD

Two figures (trees), identical in height are set out on the table at an interval of approximately 50 cm. The subject is asked simply whether the trees are 'near one another' or 'far apart'. Care is taken not to refer to movement or distance travelled. The trees should remain in the same place throughout the experiment.

Once the subject has replied that the trees are either 'near' or 'far apart', a screen is placed between them. The screen is a little taller than the trees which remain in their previous positions. The subject is then asked whether the trees are still as 'near' or as 'far apart', depending on his previous reply, and he is asked to give reasons for his reply. The screen is removed and replaced with other objects such as a screen with a 'window' in it, a large cube that is higher than the trees, several 'bricks' which are lower than the trees and form a 'fence' between the trees, and by covering the whole interval with bricks to make a 'carpet' between the trees.

The question of symmetry is raised by asking "Is it as

.../near

near or as far (using the subject's own formulation) from there to there (AB - a tree to an object) as it is from there to there (BA - the object back to the same tree?)". The experimenter runs his finger along the distance AB and BA to avoid misunderstanding. The subject is then presented with two figures where one (B) is twice as high as the other (A). The subject is then again asked if, as the objects face each other, if B is as near to or as far from A, as A is to B. Lastly, the subject is presented with two figures where one is raised 50 cm above the table level so that they are now at different levels. Any mention of climbing up or down is avoided. The subject is again asked if AB = BA.

4.3.3. STAGES OF DEVELOPMENT

STAGE I - Absence of overall distance

In this stage, subjects do not bring together the two distances of AS, BS (A and B representing trees, S the screen/mediating object) such that the distance relation between A and B has no meaning when the object is interposed. Furthermore, the distance relationship is asymmetrical (AB, BA) when the objects A and B are on different horizontal planes and even sometimes when

.../they

they are on the same plane.

Subjects cannot join the two intervals of AS and SB to obtain an overall distance, because intuition is irreversible - resulting in operational composition also being impossible - such that once something has been broken into its parts, it cannot be reconstructed as a whole. Distance is an empty space; an interval that is free from objects, and thus as soon as an object S is interposed between A and B, there is no longer a distance relationship between A and B. The subject is unable to compose the distance relations of AS and BS because the object S is in the way.

With the symmetrical property of distance (AB = BA), two situaitons must be distinguished. Where A and B are on the same horizontal plane, subjects fail to understand whether the distance from A to B as being the same as B to A because their conception of the relations of order is not reversible. In the alternate situation, where one of the objects is higher than the other, either by being taller or situated higher, distances seem greater in an upward than a downward direction. Most subjects judge the distances of the objects from themselves, thus failing to compare the

.../distances

distance of AB and BA.

STAGE II

This stage presents the core of the problem in the conservation of distance. Subjects are able to compare the reciprocal distances between A and B with the interposed object S, however, they maintain that the overall distance (AS + BS) must vary with the thickness of S. Furthermore, a difference in height between A and B demands a belief that the distance between the objects is asymmetrical.

SUB-STAGE IIA - Non-conservation of overall distance, distance relations asymmetrical

Here, as in stage I, subjects lack a co-ordinate system with which they refer to objects which occupy 'room', or unoccupied space. The first stage in the construction of this system is to recognise that although solid objects may be placed in various positions, each of them must occupy a particular 'site' which remains constant, (as noted in the conservation of space). Furthermore, a simultaneous grouping of relations of order and change of positions is required before subjects can compare lengths and distances. In this stage,

.../subjects

subjects do not compare lengths and distances - here subjects make judgements of the lengths of objects in terms of the order or positions of their boundaries and judge distances in terms of intuitive intervals between objects. Failure to conceive of a constancy between the 'sites' of objects and empty spaces leads to their non-conservation of distance.

However, unlike subjects in stage I, here subjects begin to construct an overall relation of the distance between objects A and B instead of being totally confined to the relations of each of the figures A and B and the screen S. This is not indicative of an operation because they are still sure that the introduction of S alters the distance between A and B. All subjects believe that the distance is reduced by an amount that is equal to the width of S. In addition, as in stage I, the distance between AB and BA is perceived as asymmetrical.

SUB-STAGE IIB (TYPE A) - Non-conservation of overall distance. Distance relations symmetrical

In this category, like subjects of stage IIA, distance and length is considered as being heterogeneous with distance referring to empty spaces and length to solid

.../objects.

objects. Thus the interposition of S between the end-points of A and B leads to a non-conservation of distance. However, subjects recognise the symmetrical character of the interval and the equality of the distances AB and BA. In other words, whether A and B are the same size or situated on the same horizontal plane or not, subjects are aware that AB must equal BA.

SUB-STAGE IIB (TYPE B) - Conservation of overall distance. Distance relations asymmetrical

Subjects of type A discover the symmetry of the intervals AB and BA before the conservation of distance, whilst subjects of type B make these discoveries in the reverse order. Here the conservation of distance AB with the interposed S is recognised, but they fail to agree with this when A is higher than B, or when they are asked to compare the distances AB and BA.

Although the conservation of overall distance and the symmetry of intervals are interdependent concepts at stage III, initially these concepts develop independently (hence the differences that can occur with type A/ type B in sub-stage IIB); at the level of intuition there can be progress in one of these areas without a

.../corresponding

corresponding progress in the other.

STAGE III - Conservation of distances

Responses at this stage show the conservation of distance between two stationary objects (A and B) whatever objects are interposed as S. Distance is recognised as being the same in both directions of AB and BA. There is a realisation that the dimensions of solid objects are a part of distance.

4.4. CONSERVATION OF LENGTH

Central to measurement is the notion that objects remain constant in size despite any changes in position. Conservation of length can be seen almost as an elaboration of the operational system constructed for the conservation of distance. As in the conservation of euclidean space and distance, where the subject must construct a system of 'sites' (which acts as an independent medium) that can be filled with objects, the conservation of length can only be realised if the 'site' of an object maintains constant size when it is left empty and when it is occupied by an object. Thus not only is a stable system of relations between objects established (i.e. the relations of distance) but also a system that holds the length of objects constant when objects are moved.

4.4.2. METHOD

The subject is shown two straight sticks, identical in length and about 5 cm long, with their extremities facing each other. The subject is asked to confirm that the sticks are of equal length. One of the sticks is then moved forward 1 or 2 cm, and the subject is asked which of the two sticks is longer or whether they

.../are

are of the same length. At all levels the sticks are judged equal before being staggered.

4.4.3. STAGES OF DEVELOPMENT

STAGE I

Subjects of this stage are concerned, when comparing these lines, exclusively with their end-points. Both ends of the sticks are not taken into account simultaneously, which implies that they are unconcerned with the intervals of length existing between these end-points. Changes of positions as conceived at this stage, lead to the non-conservation of length. The path of movement is thought of only in terms of the point of arrival, without any reference to the point of departure and the interval between the departure and arrival points being made. Consequently the lengths of the objects themselves change as a function of their end-points.

SUB-STAGE IIA

This stage demonstrates all the intermediate responses between stage I and stage IIB. Again after a change in position, subjects maintain that the stick which has been moved forward is longer, thinking only in terms

.../of

of the further extremities and ignoring the nearer extremities.

SUB-STAGE IIB

This stage shows what Piaget calls an 'intuitive regulation' taking place, which relates to the decentration of attention - subjects begin to take into account all extremities of the sticks, rather than concentrating only on the leading extremities. However, even where the subject begins to recognise that the sticks are equal, he may not regard them as being equal to what they were before. Some subjects come even closer to conservation by noting that the sticks are equal when in exact alignment with each other, but deny this equality when one stick is positioned at an angle of 45 degrees from the mid-point of the other. In other words, the conservation of length is being guessed intuitively, without it being regarded as a logical necessity.

SUB-STAGE III - Comparison of length. Two straight lines staggered. Operational conservation

In this stage a reference system of stationary sites and moving objects is constructed. Conservation of length now becomes a logical necessity applied in all instances.

4.5. CONSERVATION OF TIME

To determine time, an appeal must be made to causal operations, i.e. a chain must be established between causes and effects, by explaining the latter in terms of the former. Time can be seen as the co-ordination of motions at differing velocities; consequently the construction of time begins with a correlation of velocities. The operational co-ordination of these motions - physical and human motions - leads to the construction of the concepts of physical and psychological time. Although the development of psychological time involves physical time as the co-ordination of action performed at different rates implies that some work has been done initially, psychological time can be seen to be mainly of a qualitative kind, whilst physical time is of a more quantative nature. Operational time logically requires that the relations between simultaneity, succession and duration must first be constructed.

4.5.2. METHOD - THE EQUALIZATION OF SYNCHRONOUS DURATIONS AND THE TRANSITIVITY OF EQUAL TIME RELATIONS

For this diagnostic battery, the relations of simultaneity and duration will be analysed. Piaget shows that

.../even

even when a child appreciates that two bodies start and stop simultaneously, he does not necessarily conclude that their motions are of equal duration. To analyse this, a large vessel (reservoir) is allowed to empty through a tapering tube that yields two identical jets of water. The water is collected in bottles of different shapes and dimensions. Both jets of water are controlled by a single tap such that the water can be clearly seen to start and stop running simultaneously. Thus, if the two bottles are of the same shape and dimensions, the water will rise to the same level in both. In this case the equality of the synchronous durations is generally recognised. However, if the two bottles do not have the same shape, the equal quantities of water do not rise to the same level and subjects of lower conceptual development will deny the equality of time that the water was allowed to flow into each bottle. In this task, questions are asked about the synchronization of the flow of the water, the equality of the durations of flow, and the relations between time and the amount of water run out.

Before the tap is turned on, the subject is asked which of the two dissimilar bottles will be filled more quickly and if it would take more or less time to fill than the other. When water in one of the bottles (A)

.../has

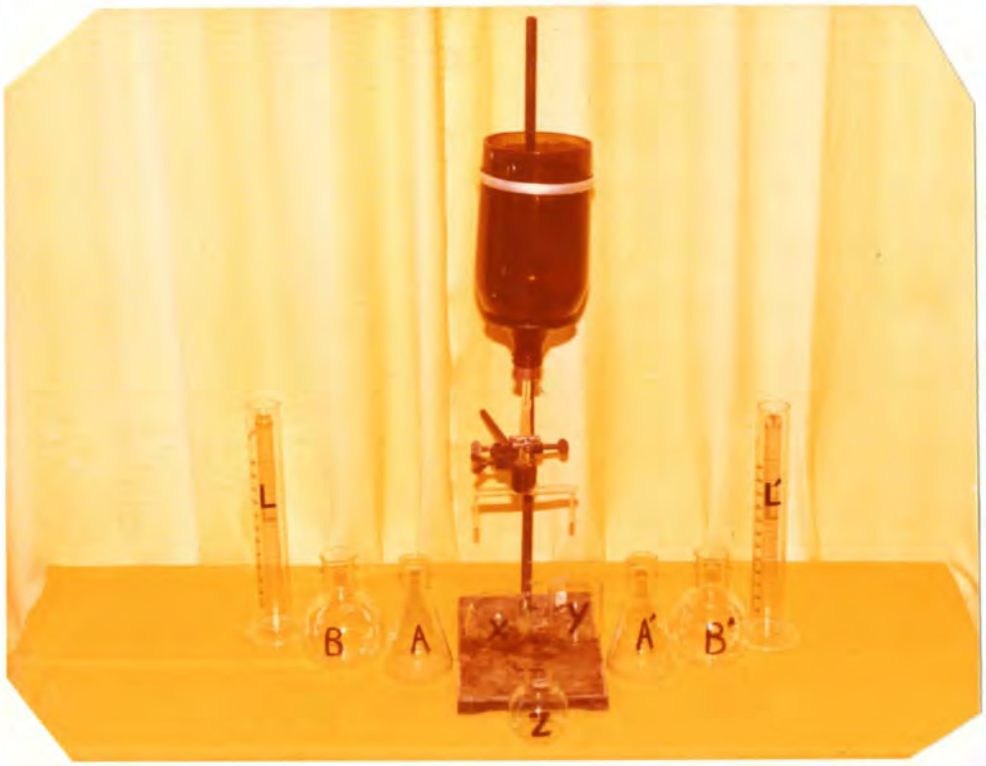
has risen to A_1 (and the water in the alternate bottle has risen from B_o to B_1; where A_1 and B_1 represent equal quantities of water), a second question is asked regarding simultaneity: 'Did the water start and stop flowing at the same time from both tubes?' A third question, 'Did the water take some time to go from here (A_o) to there, and did it take the same, or more or less time to go from B_o to B_1?'

Care is taken to make sure that the subject fully understands that the two flows are simultaneous, by the experimenter pointing out and getting the subject's agreement that the water started and stopped flowing into the bottles at the same time. Once this is agreed, a fourth question is asked: 'Is there the same amount (or the same water) in here ($A_o - A_1$) as there is in there ($B_o - B_1$), or is there more water in one of the bottles?' To check the answer given, the subject is asked: 'If this water (A_1) is poured into B´ (another vessel identical to B) how high would the water rise? If we poured this water (B_1) into here (A´) how high would that rise?' A fifth question is then asked: 'If this water (A_1) is poured into L (an elongated tube) and that lot (B_1) into L´(L = L´), would it rise to the same height or not?'

.../Finally,

Finally, to check the transitivity of operationally constructed relations of time, a sixth question is asked: 'If X takes the same time to fill as Y, and Y takes the same time to fill as Z, does X take as long to fill as Z, and do they contain the same amounts of water?' (where X, Y and Z represent flasks of different shape but the same capacity).

Figure 4 - Reservoir and Bottles



4.5.3. STAGES OF DEVELOPMENT

STAGE I - Failure to grasp simultaneity and synchronization, and failure to quantify flow

.../This

This stage shows the most primitive reactions of failure to grasp simultaneity and synchronization and above all, a complete inability to quantify the flow of water (the work done). Subjects in this stage, although realising that the opening/closing of the tap starts/stops the flow of water into each bottle, are nevertheless unable to accept the simultaneity of the end of the flow. Piaget points out that failure to grasp simultaneity goes hand in hand with a failure to synchronise durations because the subject thinks of time as belonging to each action separately, and furthermore, that actions can only be co-ordinated by their results (i.e. the work done). However, as results cannot yet be quantified, they cannot serve the subject as objective criteria by which he can judge time durations and intervals etc. Duration is thus evaluated by the results of an action (in this case the levels of the liquid - irrespective of the size of the bottles). These results do not depend on the interval between the starting and finishing points, but merely on the finishing point alone.

SUB-STAGE IIA - Inverse relation between time and velocity and correct prediction of the filling rate as a function of the size of the bottle; simultaneity but neither

.../synchronization

synchronization of durations nor correct quantification of the flow of the liquid

Subjects at this sub-stage usually succeed in answering the first two questions correctly, but none of the others. Thus, at this stage, subjects recognise simultaneity and by divorcing time from velocity predict intuitively that the larger of the two bottles will be filled more slowly and in greater time. However, they fail to synchronise durations with simultaneous starting and stopping points, or to quantify the amounts of water run out. In this stage subjects begin to make a distinction between the results of the action and its duration and consequently they expect the larger of the two bottles to take more work to fill than the smaller one. Where in stage I, subjects deny simultaneity because they centre their attention on the rising levels of water and not the stopping of the flow, in stage IIA this simultaneous stopping of the two water flows is taken into account as well as the rise in water levels. This decentration leads subjects directly to grasping simultaneity.

At this stage, subjects are still unable to establish the equality of the durations until they have developed a conception of quantity that would enable them to re-

.../alise

alise the equality of the two amounts of water that were run out.

SUB-STAGE IIB - The empirical discovery of synchronization

At this stage, subjects succeed in grasping the equality of synchronous durations and of the quantities of liquid run out, but only after a succession of trials and errors. However, this achievement does not imply that subjects have fully grasped the idea of synchronization. It is not yet an operational construction; it is still to an extent intuitive and empirical, lacking in generality. Some subjects may discover the synchronization of the durations of the flow of water, and then use this to immediately deduce the equality of the amounts of water (quantification of the work done), whilst other subjects may make this discovery in the reverse order; discovering first the equality of the quantities of water and then the synchronization of the durations.

STAGE III - Immediate synchronization and quantification

This stage reveals the operation construction of the relations of time, and demonstrates that the greater the grasp of synchronization, the better the quantifica-

.../tion

tion of the work done. To ascertain whether a subject's responses are operational (and not merely intuitive) requires a close examination of the responses to question six - which poses a problem of transitivity. Subjects must construct relations of time operationally before they can appreciate that the equations of X = Y and X = Z are transitive. Piaget points out that none of the subjects he tested could solve the problem of X = Z, before they were able to answer questions I to 4 correctly.

4.6. THE CONSERVATION OF SPEED

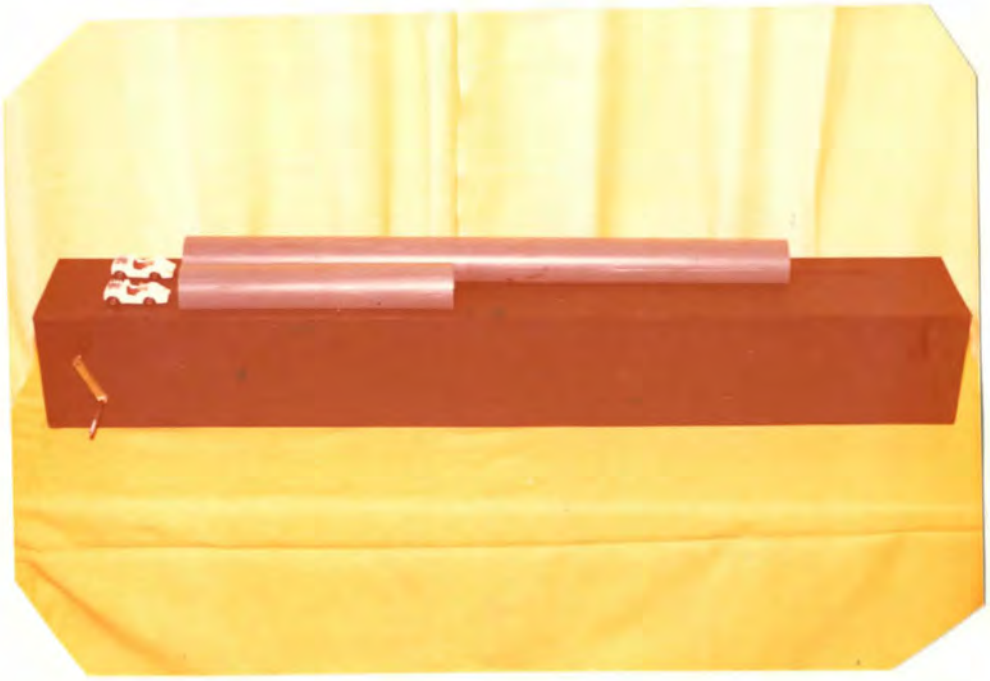
Piaget claims that the simplest intuition of speed and movement rests on an intuition of order; a moving object is judged to be faster than another when it overtakes it on a path parallel to its own (when it was originally behind or side by side of the other object according to the direction of travel, and is afterwards ahead of it).

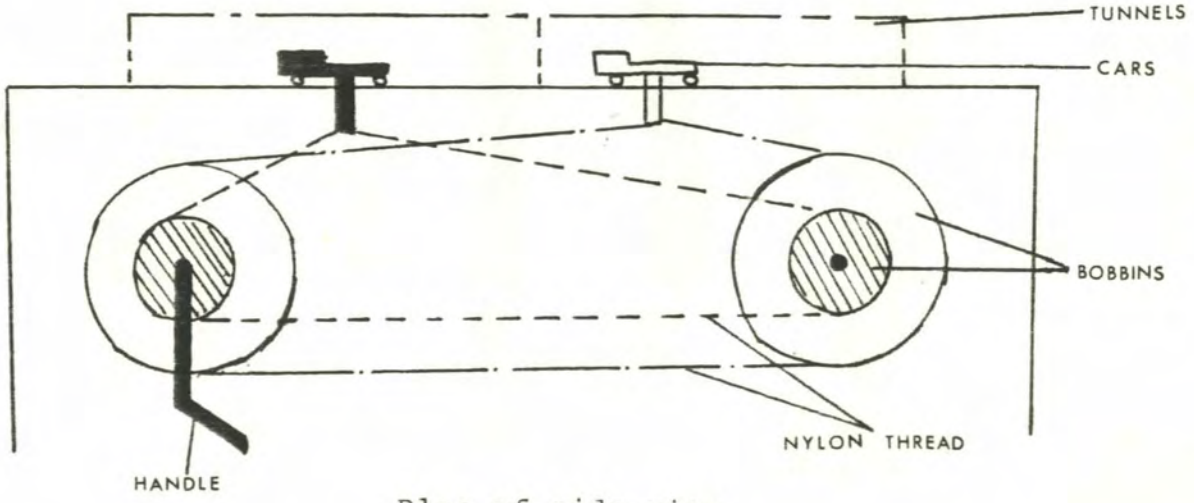
4.6.2 METHOD - THE SPEED OF TWO MOVEMENTS WHERE ONLY THE STARTING AND STOPPING POINTS ARE VISIBLE

The task used here involves judging the respective speeds of two moving objects when the starting and stopping points alone are visible. The paths are unequal in length, but parallel, whilst running in the same direction and remaining out of sight of the subjects (i.e. the use of two tunnels of unequal length). Subjects are shown the two straight tunnels (36 inches and 18 inches in length) and two identical toy cars. The cars are moved by turning a handle controlling two bobbins of differing diameters, winding up nylon threads which are attached to the cars. (See figure 5).

.../Figure

Figure 5 - The cars and tunnels.





Plan of side view

By moving the handle backwards or forwards the cars can be moved back to their starting points or onto their stopping points. The ratios of the diameters of the bobbins allow for differing speeds in the movements of the cars such that they are able to start and stop together whilst travelling unequal distances.

Subjects are shown the two straight tunnels with the cars placed at their entrances (side by side along the same starting line). Care is taken to point out to the subject the disparity in the length of the two tunnels, requesting the subject to point out the longer of the two. Furthermore, the subject must be seated in such a way in order to keep a watch on the two exits and entrances of the tunnels, and he himself gives the starting signal. The cars are then moved off through the tunnels to stop simultaneously at their differing stopping points. The questions then asked are whether one car went faster than the other; did they travel for the same length of time and which car travelled the furthest etc. If the subject clearly fails to solve the questions on speed, the two movements are repeated with the tunnels removed, and when the subject has seen which of the two cars was moving faster, and has explained why, the tunnel apparatus is replaced

.../and

and the original questions put again as before.

4.6.3. STAGES OF DEVELOPMENT

STAGE I - Failure in comparison of speeds

In this stage the subject fails to solve the problem of the tunnels, even after seeing the cars travel the paths in full view. Intuitive solution of speed (as opposed to operational solution) is demonstrated by the fact that subjects of this stage have no difficulty in recognising that one of the cars moves faster than the other when the cars are in full view (with tunnels removed). However, this only holds provided the cars are set off simultaneously from the same point and travel in the same direction. In other words, greater speeds are only attached to visible 'overtaking'.

Piaget points out that subjects at this stage, in observing the simultaneous stopping of the cars, tend to judge the speeds as equal even if one moving car is set off after the other from the same starting point. Some subjects at this stage claim that the car travelling the longer distance takes the longer time, even though they have seen the simultaneousness

.../of

return to the experiment using the tunnels they immediately transpose what they have realised and have no difficulty in grasping from the length of the bigger tunnel that a hidden overtaking is taking place, and thus deduce that the object is travelling at a greater speed. However, this realisation is not yet operational in that they still think in terms of real overtaking and do not correlate the time and space traversed.

STAGE III - Operational solution of the problem

In this stage subjects manage to establish the difference in speeds by immediately correlating the given factors of time and the space traversed. Piaget claims that even here the criterion of speed is the overtaking, but it is an invisible, operational overtaking as the orders of succession of 'ahead', 'behind' and 'after' are translated into intervals or lengths that are a direct result of the translation of the lengths that are perceived (in this case the lengths of the tunnels). In taking cogniscence of the equality of the synchronous durations, overtaking thus becomes the relationship of the space traversed and the intervals of time. Consequently there is no further need to imagine any overtaking inside the tunnels. The distance travelled and the time taken are directly correlated into speed.

.../4.7.

of starting and stopping.

Intuitions of speed do not consist of relationships of distance and time, but rather of perceptions of 'overtaking' which is a practical rather than an intellectual relationship. When the tunnels are replaced and the subject is again unable to compare speeds, the subject is unable even to imagine the potential overtaking of the cars inside the tunnels, as this requires a necessary consideration of the idea of lengths and their relations to the equal durations (time).

In general, subjects at this stage, being restricted to the field of perception, consider the two speeds to be equal by centrating on the simultaneousness of the starting and stopping points.

STAGE II - Intermediate responses

Subjects of this stage begin as in stage I by judging the speeds to be equal, and then gradually move towards a correlation of time and the distance travelled. Here, when the subjects see the movements repeated without the tunnels, they begin to realise that as one object traverses a greater space than the other, it in fact overtakes the other. Consequently then they

.../return

4.7. UNIFORMLY ACCELERATED MOVEMENT

Once the subject has successfully conserved operations of speed, the way is then open to the acquisition of the concept of acceleration. The easiest method of studying acceleration is to look at uniformly accelerated movement on an inclined plane. The conservation of acceleration requires the co-ordination of relations of distance, time and speed.

4.7.2. METHOD

Subjects are shown two parallel tracks (roads) with two identical toy cars. The tracks can be inclined independently at either end, to various angles, representing downhill and uphill slopes. One track is then inclined, and the primary question is to find out how the car comes down the slope, and if its speed always stays the same. Once the subject has discovered that the speed of the car changes as it rolls down the slope, the slope is marked with flags at equal distances (four intervals) and the second question is to discover on which of these intervals the speed of the car will be the greatest, and what the relations of speed are from one interval to the next.

.../Question

Question three concerns the decrease in times over equal distances. The subject is asked how long the car takes to travel the first interval, then the second, the third and the last. Finally question four is asked which concerns the increase in the distances covered in equal times. Here the subject is shown the second track and the car again rolling downhill. The subject is told that the driver of the car has a watch, and every minute, whilst going down the hill, the driver shouts 'hey'. At every 'hey' a spectator at the side of the track plants a flag (four in all). The subject is asked to point out where these flags should be positioned. What is being analysed is the distances the subject allocates between the flags.

Figure 6 - The cars and slopes

To check the subject's responses, the opposite ends of the tracks can be raised, and the cars allowed to run downhill and then up the other side. The same questions are asked as before, but this time in relation to uniform decceleration.

4.7.3. STAGES OF DEVELOPMENT

STAGE I - No acceleration as a function of decent

Piaget points out that most subjects begin this task already having an intuition of acceleration, although some subjects do not have any notion of acceleration at all. In the latter case, subjects are unable to conceive an object as going 'faster and faster' or even just 'faster'. They can only entertain an idea that an object is moving at speed and that it remains constant throughout. In other words, at this stage, questions of acceleration are totally meaningless to the subject.

STAGE II - Intuitive acceleration

This stage is characterised by an empirical intuition of acceleration as a function of the incline. Piaget claims that this intuition is incomplete as acceleration is not conceived here as continuous or regular - there

.../is

is no correlation of time with the distance travelled - subjects are unable to translate their intuition of acceleration into relations of time or distance travelled (i.e. operational relations of speed). Thus in this stage, the subject either believes that the times taken for each interval are equal because the distances are, or he correlates an increase in speed with an increase in time, or he may see the distance travelled in the equal time intervals as being less and less as the pace gets faster.

STAGE III - Articulated intuition of acceleration and gradual success in correlating times and distances successively traversed

It is to be noted that Piaget makes a division of stage III into the finer gradations of sub-stage IIIA and IIIB. The responses of subjects in sub-stage IIIA are identical to those of stage II, however Piaget points out that the distinguishing factor is that subjects of stage IIIA unlike stage II, know how to correlate operationally the distance travelled with the time taken when comparing the speeds of two simultaneous movements, and they only have to be questioned on simultaneous movements and then brought back to the question of acceleration for them to begin to answer

.../correctly.

correctly. Thus, to realise this fine distinction requires the use of a further task relating to simultaneous movements. Consequently, in order to keep the diagnostic battery concise, Piaget's sub-stage IIIA will be included under stage II, whilst those subjects falling in his sub-stage IIIB, will simply be seen as stage III and no extra task will be employed.

Subjects in stage III begin by making the same errors as those in stage II (i.e. by correlating equal distances with equal times and vice versa, or by reasoning that the distances traversed diminish regularily with increasing speed), but then go on to correct their responses spontaneously. It is precisely this correction that shows that subjects have not yet fully succeeded in construing acceleration operationally. Their thinking remains, at this stage, more closely linked to simple representational imagination.

STAGE IV - Immediate solution of the problems by formal operations

In stage III, the subject's thinking is tied to the concrete - to what is actually there - whilst this stage sees the immediate solution of the problem, indicating the capacity of hypothetico-deductive reasoning.

.../Subjects

Subjects of this stage accept without hesitation that the time taken for each new equal distance decreases and that with each new equal time the distance increases.

4.8. THE CONSERVATION OF FORCE

Although Piaget does not appear to have a particular task dealing with the concept of force, the task chosen here incorporates the idea of Newton's third law of motion which requires force to be operationally construed as kinetic energy in relation to work done (where work equals force x distance).

4.8.2. METHOD - THE TRANSMISSION OF MOVEMENTS

This task looks at the immediate and mediate transmission of movements from one object to another. The task consists of a horizontal bar with eight hooks upon which wooden balls suspended on wire, can be hung. The balls used are of different sizes (one large ball, six medium sized balls, and eleven small balls). One small ball is painted a distinguishing colour (in this case silver) and the remainder are divided into two other colours. All balls are suspended on wires of three inches in length except for two small balls, where one is suspended by a long wire five inches in length and the other by a short wire one inch in length.

A short wooden ruler (three inches in length) suspended horizontally by a wire three inches in length is also

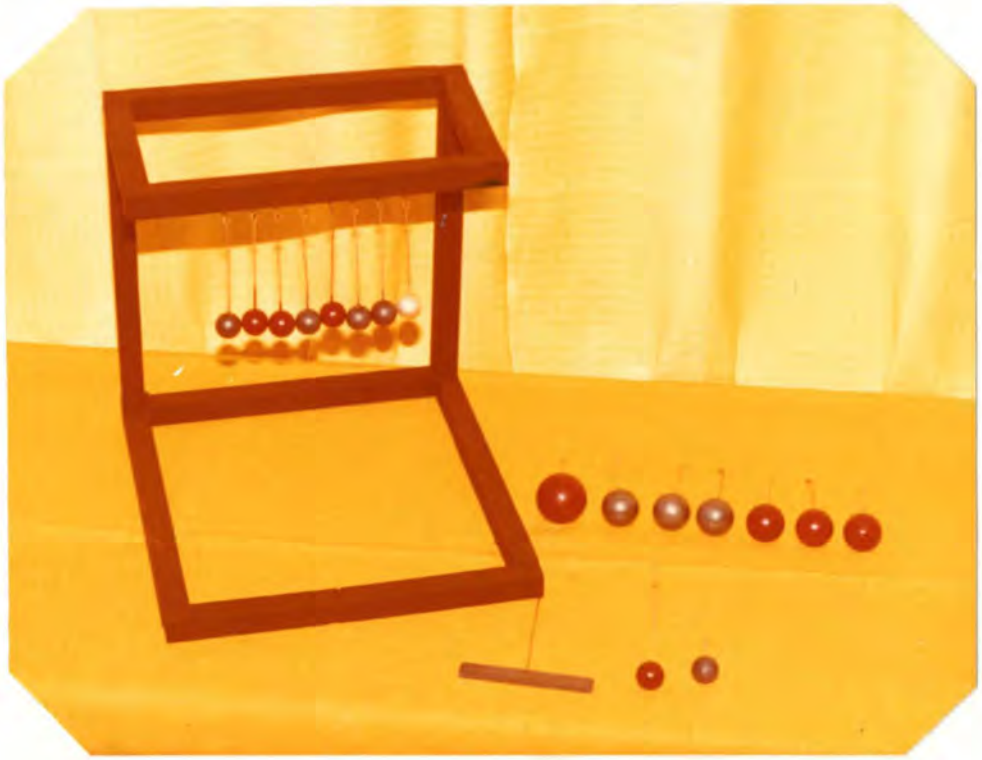
.../provided.

provided.

The subject is shown the bar with a small ball and the silver ball attached to the extremities of the row of hooks, and is asked to move the silver ball by not touching it, but by using the first ball (already attached) and any of the other objects provided. Care must be taken to impress upon subjects that the first ball plays an essential part in the experiment, and furthermore, when subjects unhook the first ball and bring it nearer to the silver ball the experimenter must immediately return it to the original hook with instructions that it should be left there. Whilst subjects are engaged on this task, they are asked what they would think would happen if they use a large ball, a medium sized ball, suspension at different positions etc. After various subjects are asked to give an account of what they have done and what has been happening to the objects. If subjects have been unsuccessful they can be finally shown the solution - to suspend small balls with the same lengths of wire on all the hooks and to strike the first one. The experimenter then observes the subject's reactions, i.e. whether the use or fail to use the solution when repeating the whole experiment.

4.8.3. STAGES OF DEVELOPMENT

Figure 7 - The transmission of movement.



SUB-STAGE IA - Centration on immediate transmission:

Subjects of this stage try to use every type of immediate transmission (direct contact between the first ball and the silver objective) or some method of extending the manual action, e.g. by exchanging the first ball for one on a longer wire. None of these subjects think of using other balls as intermedia and thus have no conception of mediate transmission. In general when these subjects are shown the solution they still fail to grasp mediate transmission. Piaget

.../points

points out that in this stage when the subject collides one ball with another, he tends to forget which one started the process which reflects a difficulty in realising the order of succession; when subjects begin to pay attention to the order of succession they are lead towards the responses encountered in stage IB.

SUB-STAGE IB - The discovery of quasi-mediate transmission

Quasi-mediate transmission refers to the idea of a chain of immediate transmissions as opposed to the idea of a force that traverses a number of moving objects. This stage marks the transition from the absence of mediate transmission to the actual discovery of chain reactions. Subjects in this stage hook up other balls or the rule as intermedia and see, for example, the first ball hitting the next and the next hitting the following object which then hits the silver objective with each action being an independent and successive impulse. This demonstrates that before subjects can conceive of mediate transmission, they must grasp the order of succession of events, thus linking up a chain of immediate transmissions.

Subjects in this stage discover that in using objects

.../as

as mediators, they are substituting an action of the object for the action of his own - they use the first ball as a substitute for the impact of the hand on the second object.

STAGE II - An appeal to mediate transmission

Subjects of this stage appeal almost directly to mediate transmission, however they tend to believe that they must use large balls to augment the force of the impact. Although the intermediate large objects do move, the deliberate selection of large balls suggests a failure to grasp the conservation of transmitted motion (and consequently an operational construction of force as mass x acceleration).

STAGE III - Operational solution of the problem

Subjects of this stage hook up intermediate balls of equal sizes (and with the same lengths of wire) to the small ball as an immediate solution to the problem. The most effective solution being to hook up small balls on all of the intermediate hooks such that all the small balls are touching each other, the first ball, and the silver ball. Consequently the minimum amount of force applied to the first ball induces movement

.../in

in the silver ball. Here subjects conceive of the solution as energy (or force) being transmitted through the intermediate objects, inducing movement in the silver ball.

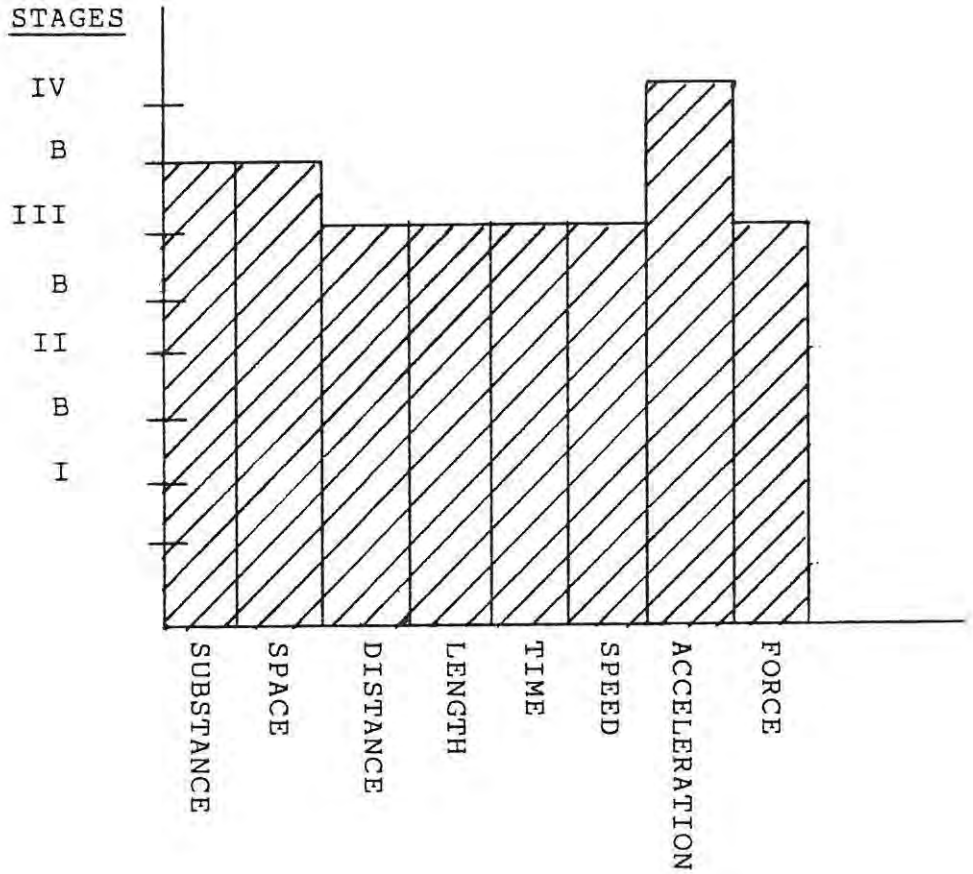
4.9 RESULTS

CATEGORY ONE

EVIDENCE OF FORMAL THINKING

FIGURE 8.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: WIN AGE: 20

FEMALE WHITE

COMMENTS

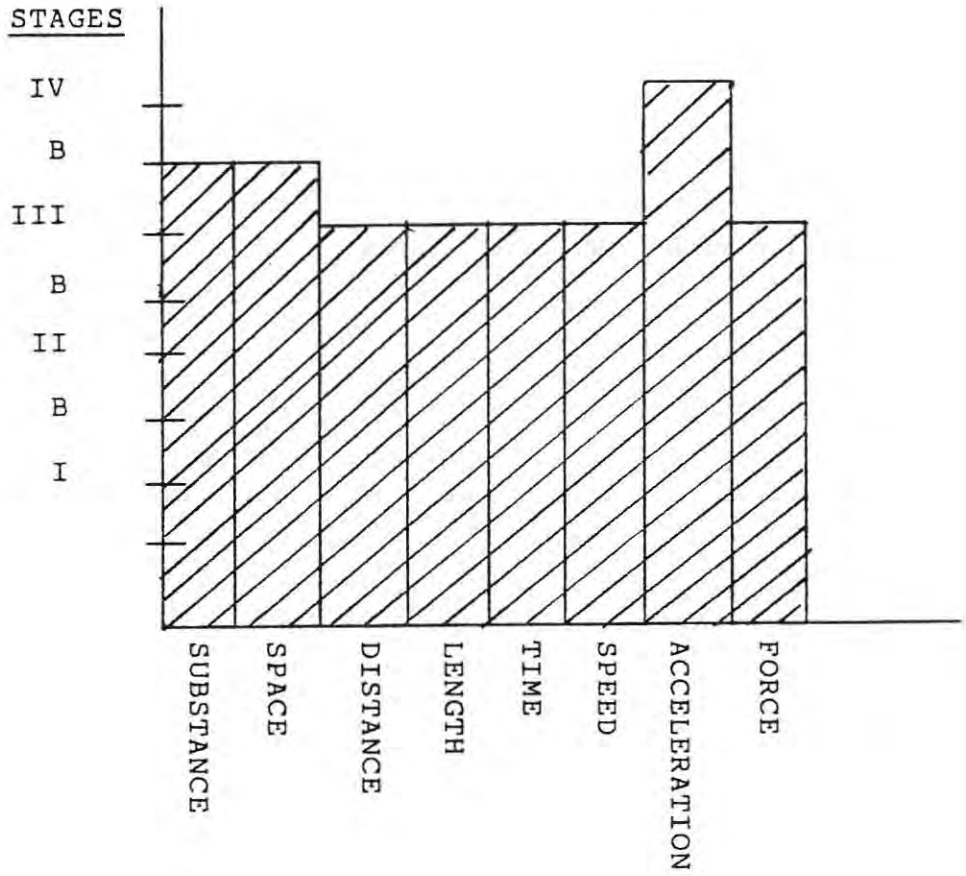
WIN's Profile is fully developed.

She found the tasks of acceleration and force the most interesting and found the tasks of substance, distance and time the most boring.

This profile shows evidence of formal thinking.

FIGURE 9.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: ROB AGE: 26

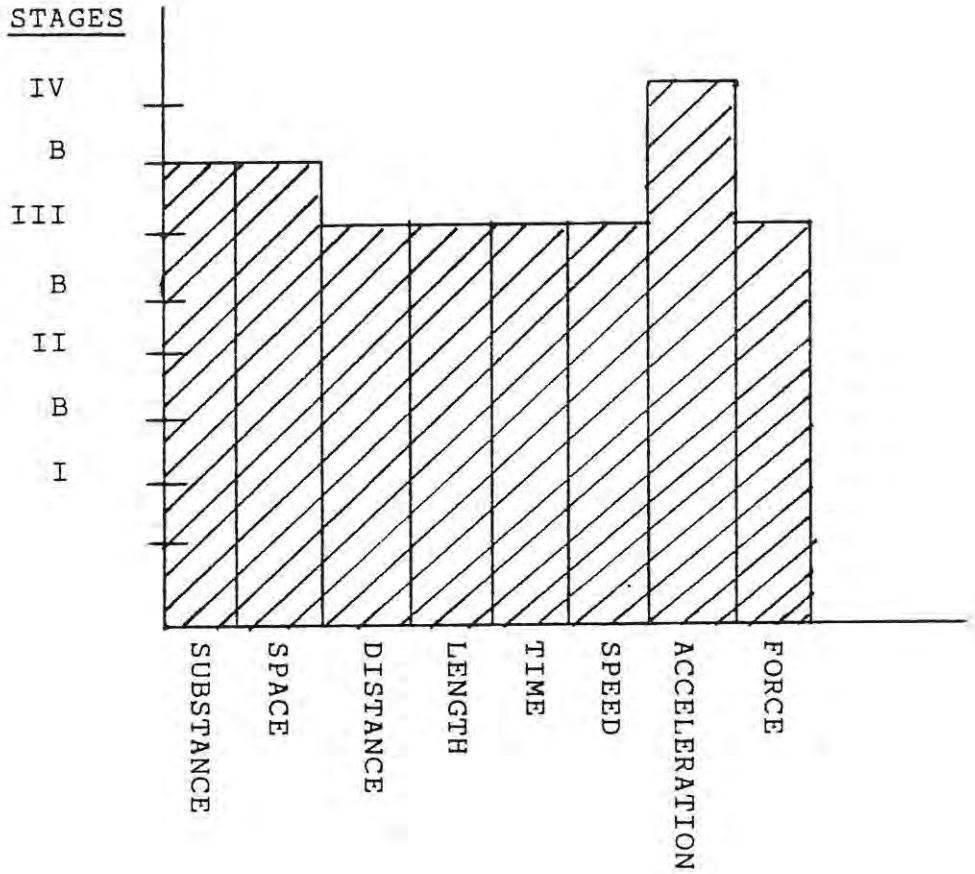
MALE WHITE

COMMENTS

ROB found force and acceleration the most interesting, and substance, space, distance and length the least interesting. This profile reveals evidence of formal and concrete thinking.

FIGURE 10.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: DWI AGE: 20

MALE WHITE

COMMENTS

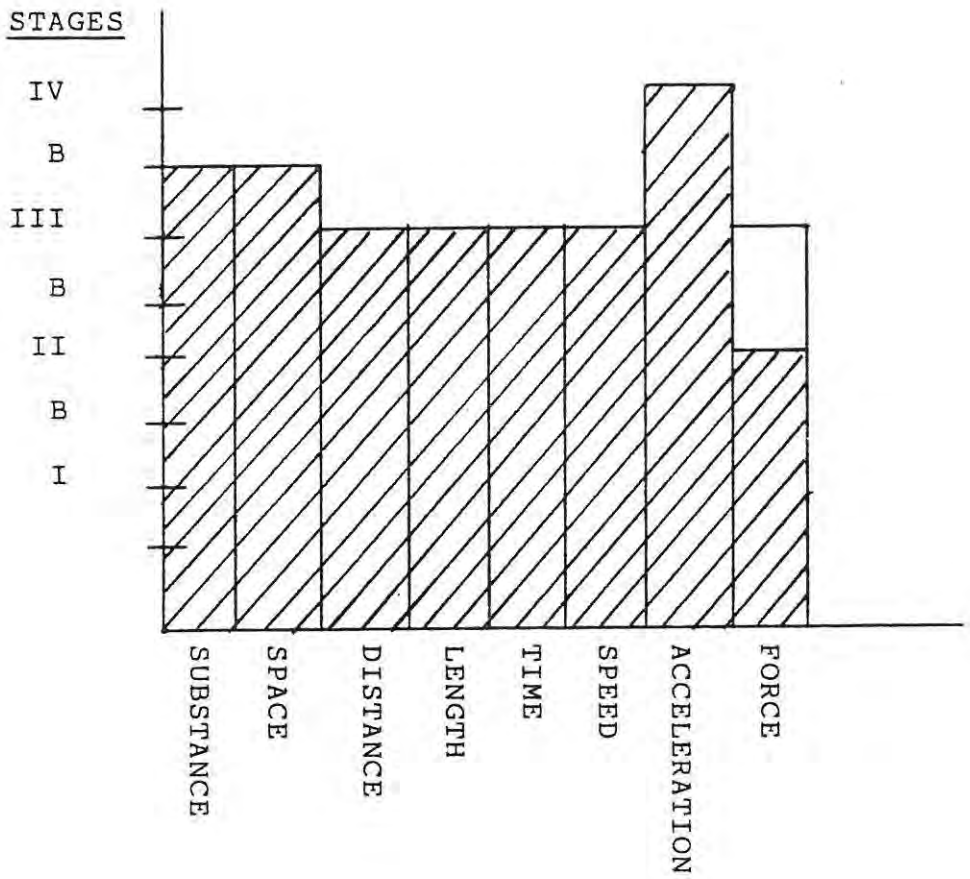
DWI's profile is fully developed.

The tasks he found most interesting were those of time, acceleration and force.

This profile shows evidence of formal thinking.

FIGURE 11.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: CHE AGE: 19

FEMALE WHITE

COMMENTS

CHE found force and acceleration the most interesting with length and substance the least interesting.

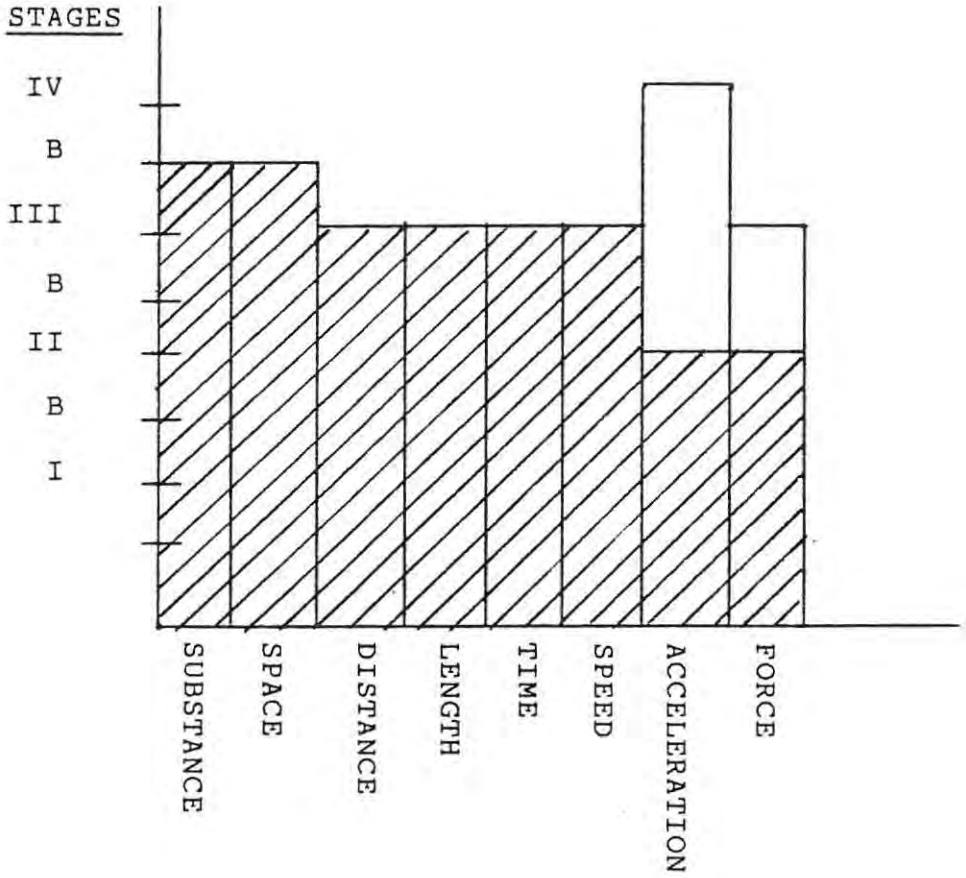
This profile reveals evidence of formal, concrete and pre-operational thinking.

CATEGORY TWO

EVIDENCE OF PREDOMINANTLY CONCRETE THINKING

FIGURE 12.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: GAV AGE: 20

MALE WHITE

COMMENTS

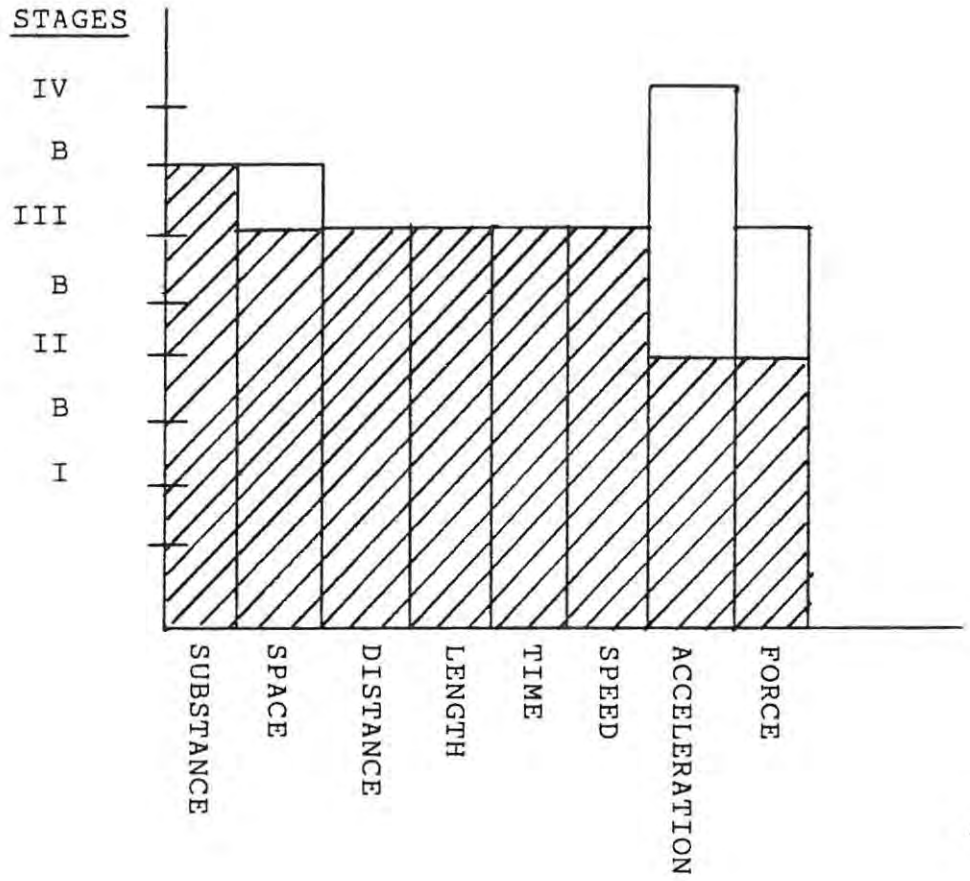
GAV found the task of force the most difficult.

He found the tasks of acceleration and space the most interesting, and the tasks of substance, distance, length and time uninteresting.

This profile shows evidence of concrete and pre-operational thought. (Acceleration and force).

FIGURE 13.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: BES AGE: 42

MALE BLACK

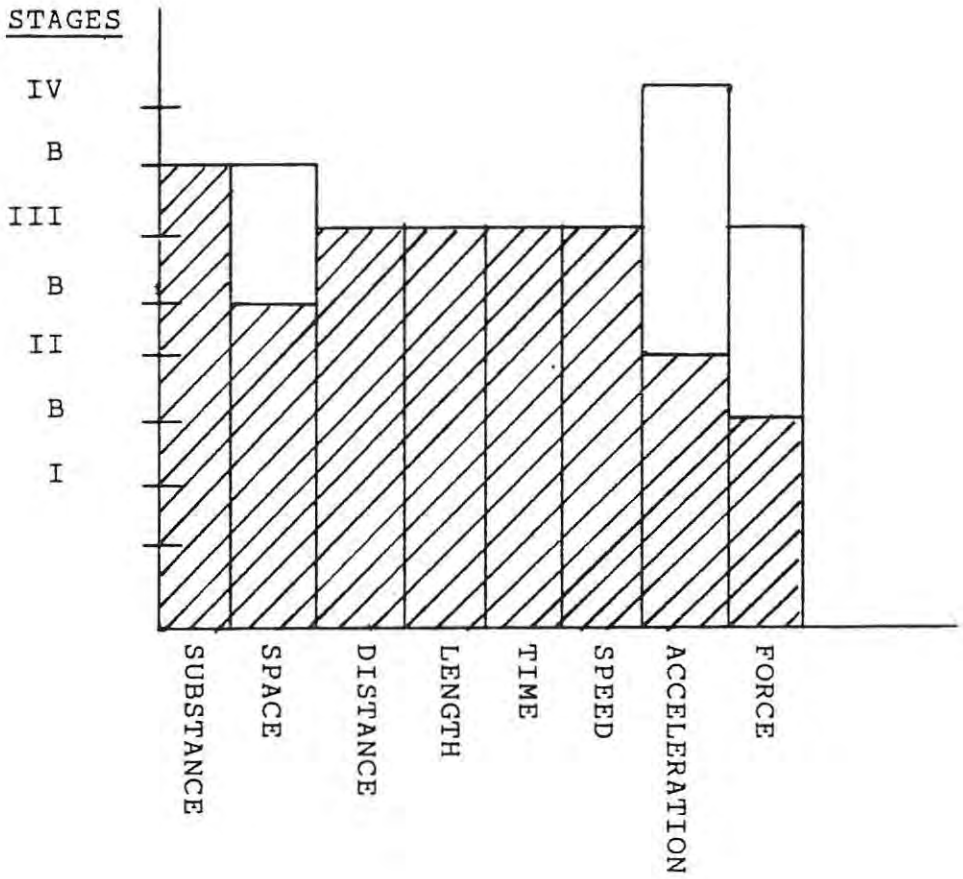
COMMENTS

BES found the tasks of acceleration and force the most interesting.

This profile reveals evidence of concrete and pre-operational thinking.

FIGURE 14.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: JEN AGE: 19

FEMALE WHITE

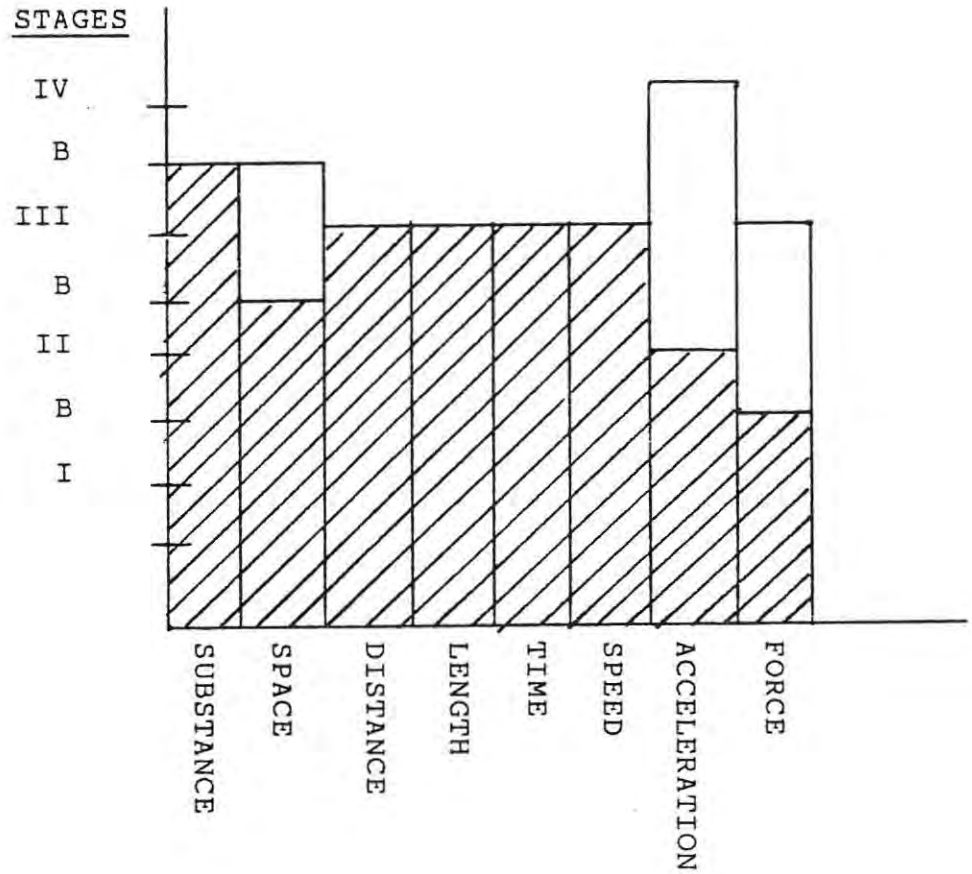
COMMENTS

JEN reported acceleration and force to be most interesting, with the tasks of length and substance being the least interesting.

This profile reveals evidence of concrete and pre-operational thinking.

FIGURE 15.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: JOA AGE: 19

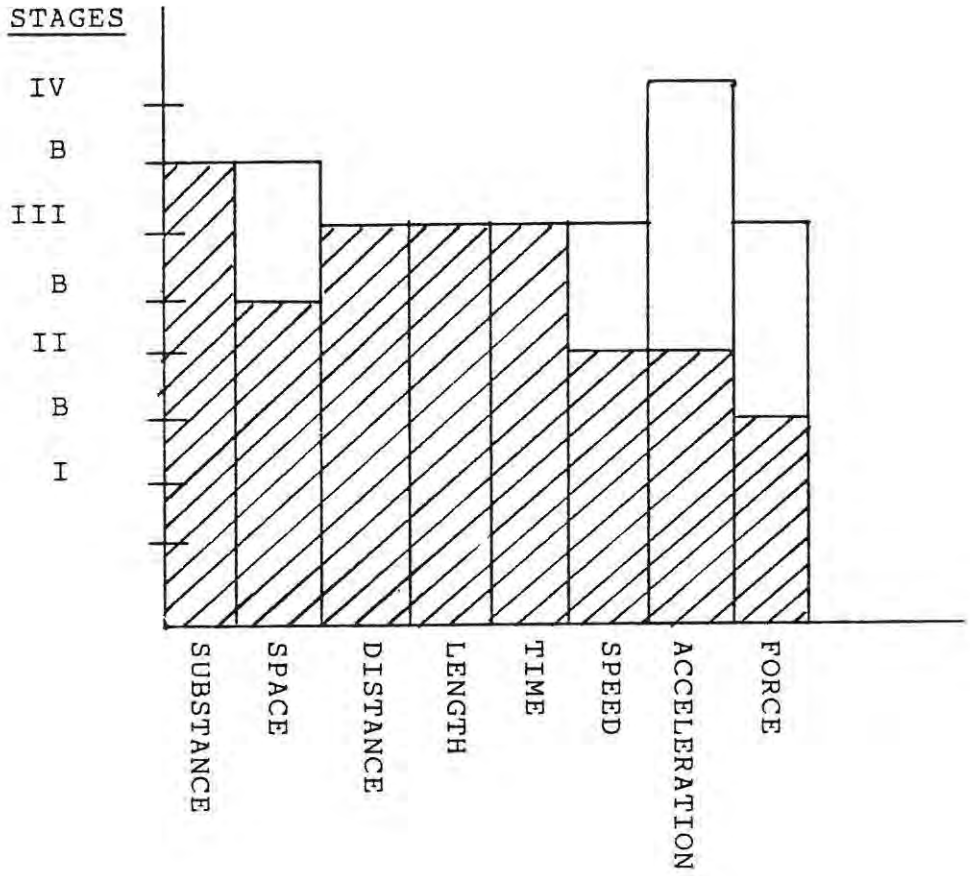
FEMALE WHITE

COMMENTS

JOA found the tasks of force and acceleration the most interesting and the task of distance the least interesting. This profile reveals evidence of concrete and pre-operational thinking.

FIGURE 16.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: ROR AGE: 13

MALE WHITE

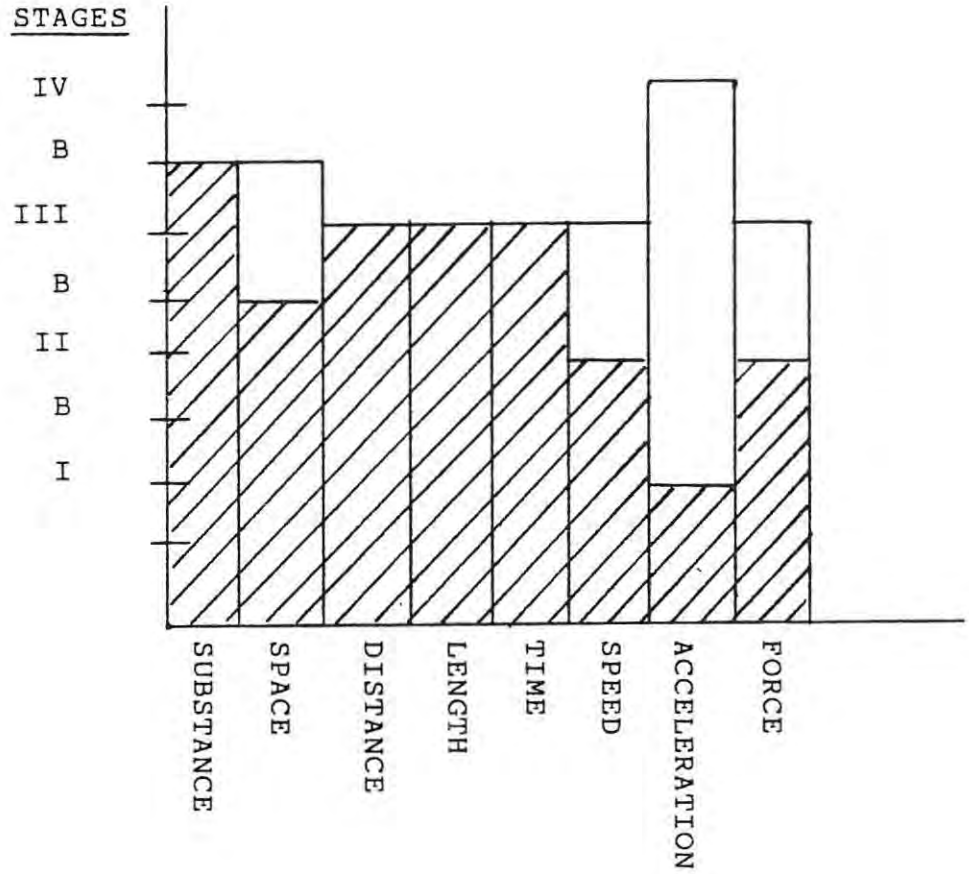
COMMENTS

ROR found the tasks of time the most interesting, without finding any tasks particularly uninteresting.

The profile shows evidence of concrete and pre-operational thinking.

FIGURE 17.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: LIN AGE: 15

MALE BLACK

COMMENTS

LIN found the task of time the most interesting.

He did not like doing the task of force.

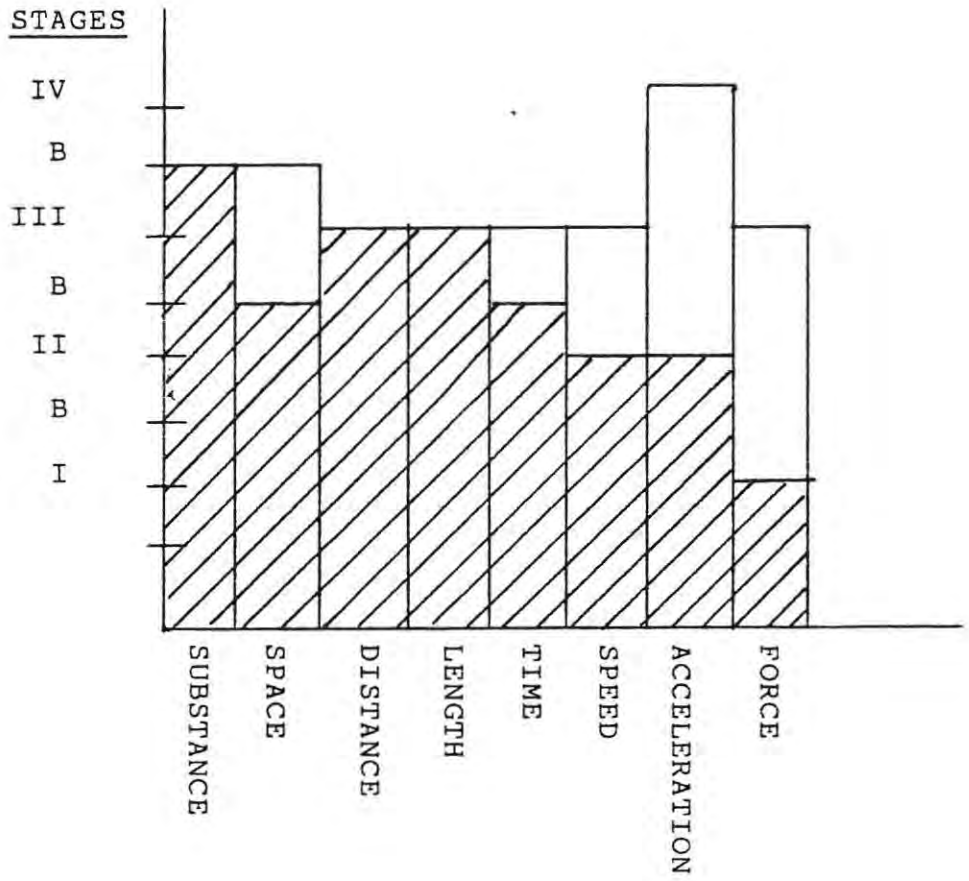
This profile reveals evidence of concrete and pre-operational thinking.

CATEGORY THREE

EVIDENCE OF PREDOMINANTLY PRE-OPERATIONAL THINKING

FIGURE 18.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: POR AGE: 15

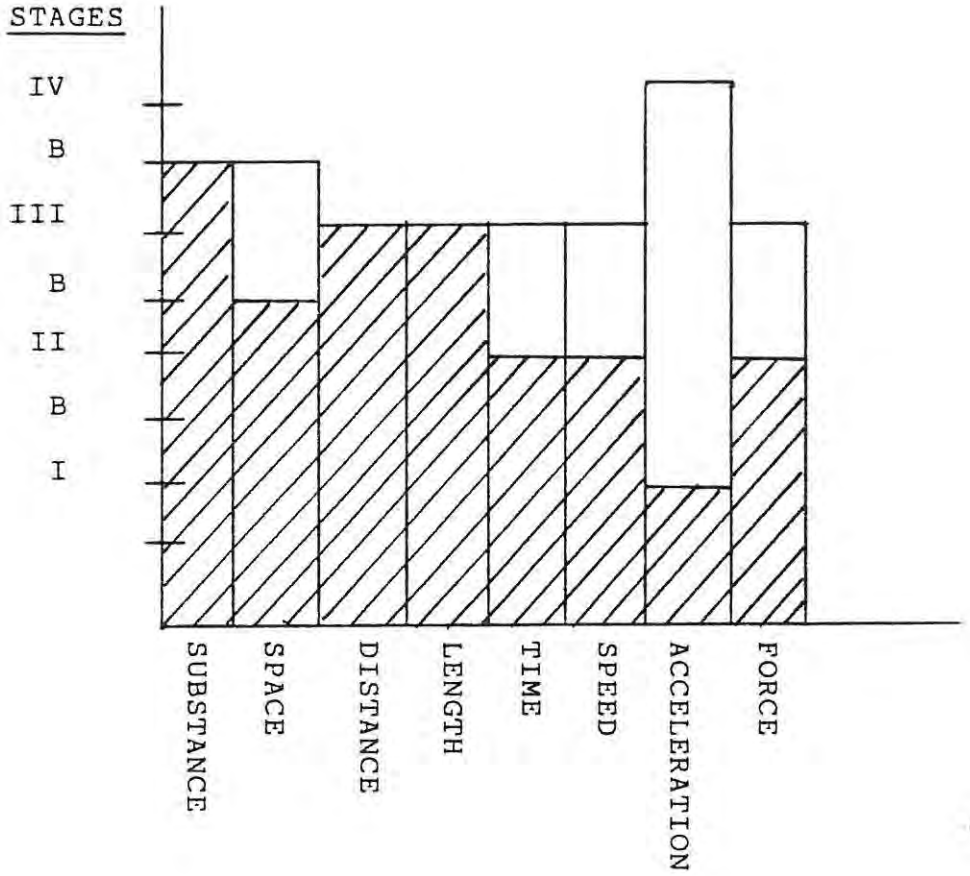
FEMALE BLACK

COMMENTS

POR found the tasks of space and time the most interesting. She disliked the task of force because it was "too difficult". This profile reveals a predominance of pre-operational thinking.

FIGURE 19.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: BEL AGE:24

FEMALE BLACK

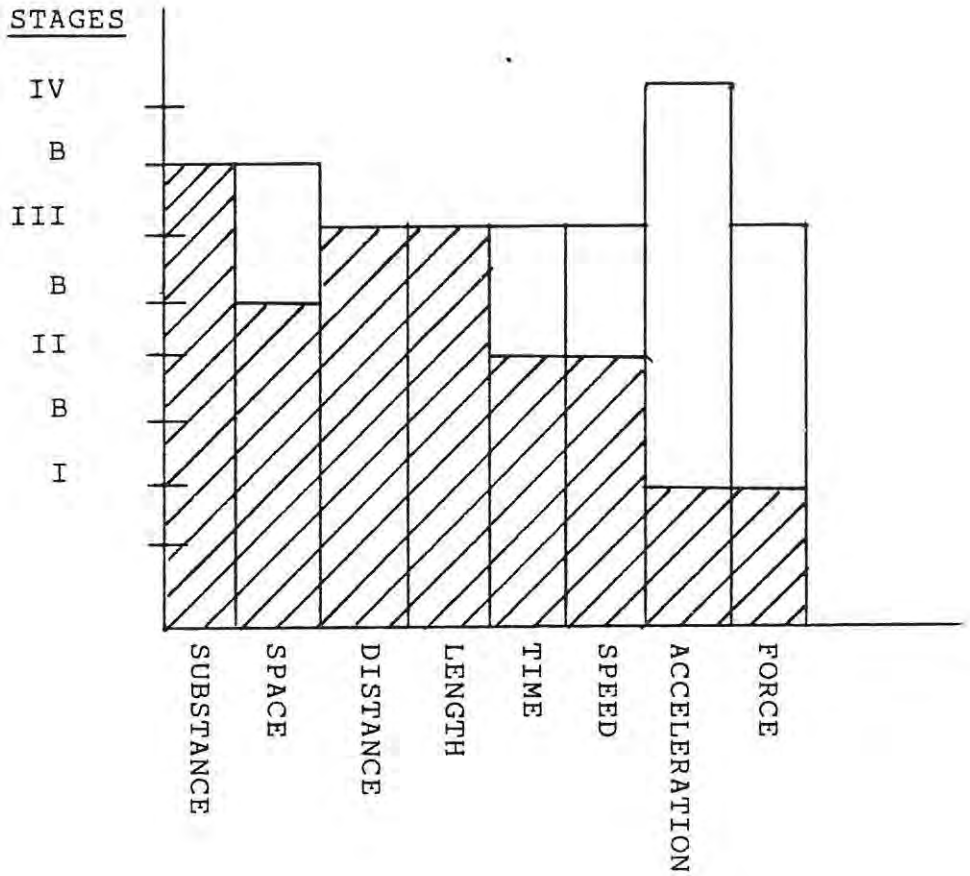
COMMENTS

BEL found the task of time the most interesting, and disliked the tasks of force and acceleration because they were "too difficult".

This profile reveals a predominance of pre-operational thinking.

FIGURE 20.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: HEA AGE: 14

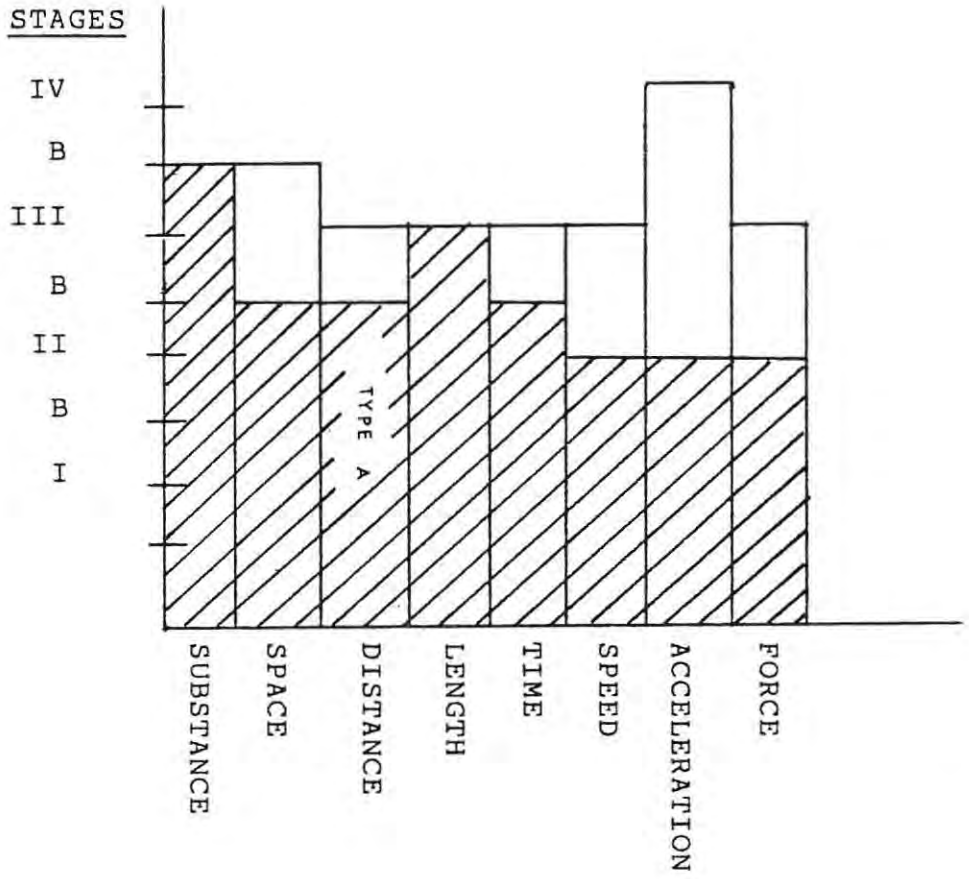
MALE BLACK

COMMENTS

HEA found the task of space the most interesting.
He did not like the tasks of acceleration and speed because they were "too difficult".
This profile reveals a predominance of pre-operational thinking.

FIGURE 21.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: ELS AGE: 44

FEMALE BLACK

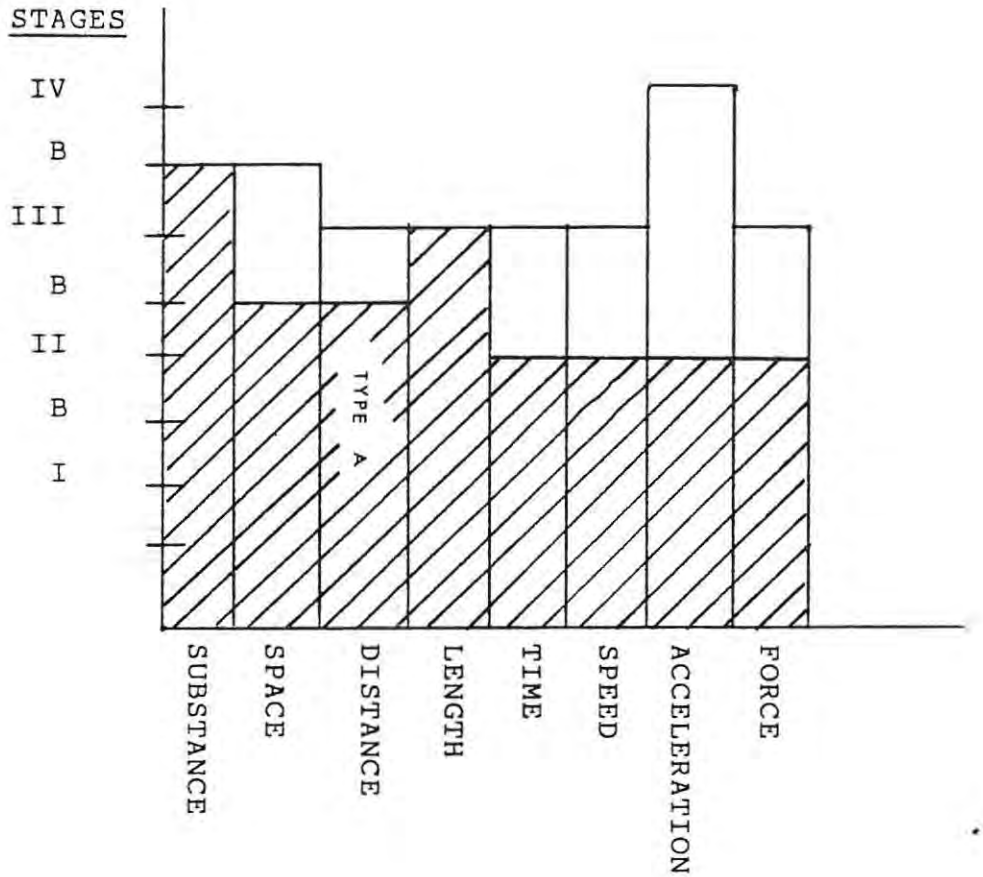
COMMENTS

ELS found the task of speed to be the most interesting. She disliked the tasks of space.

This profile reveals a predominance of pre-operational thinking.

FIGURE 22.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: JOS AGE: 27

MALE BLACK

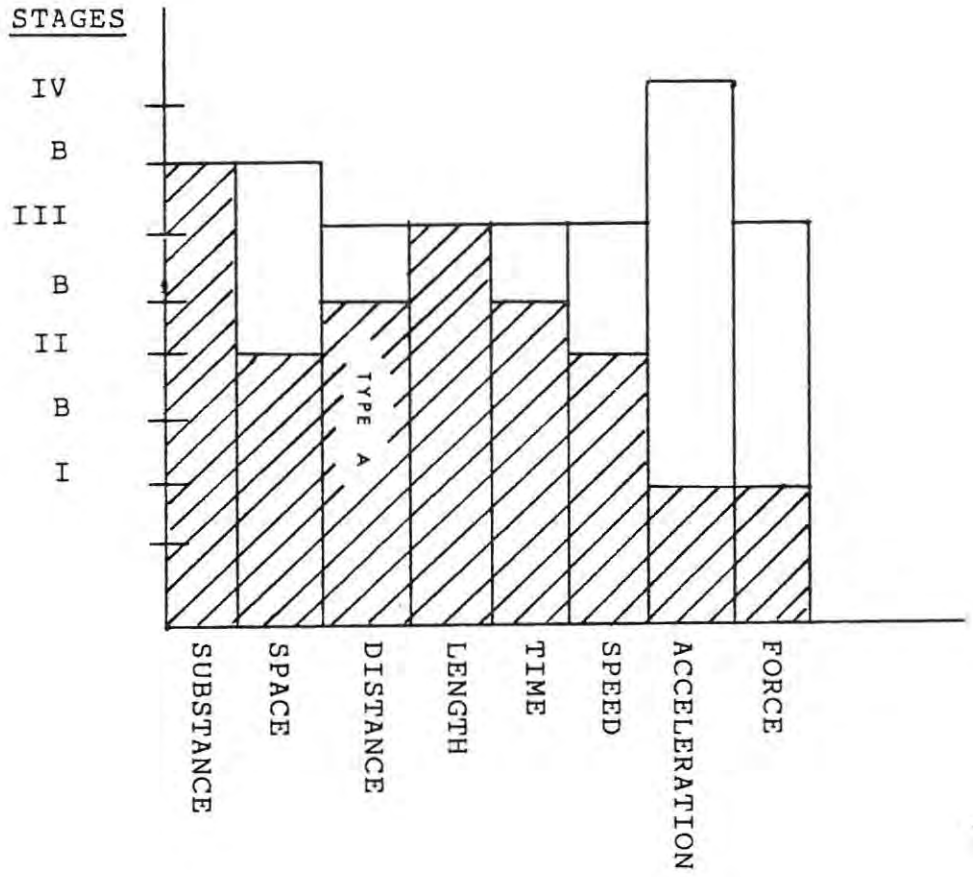
COMMENTS

JOS found the task of time the most interesting and disliked doing the task of acceleration.

This profile reveals a predominance of pre-operational thinking.

FIGURE 23.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: GLA AGE: 54

FEMALE BLACK

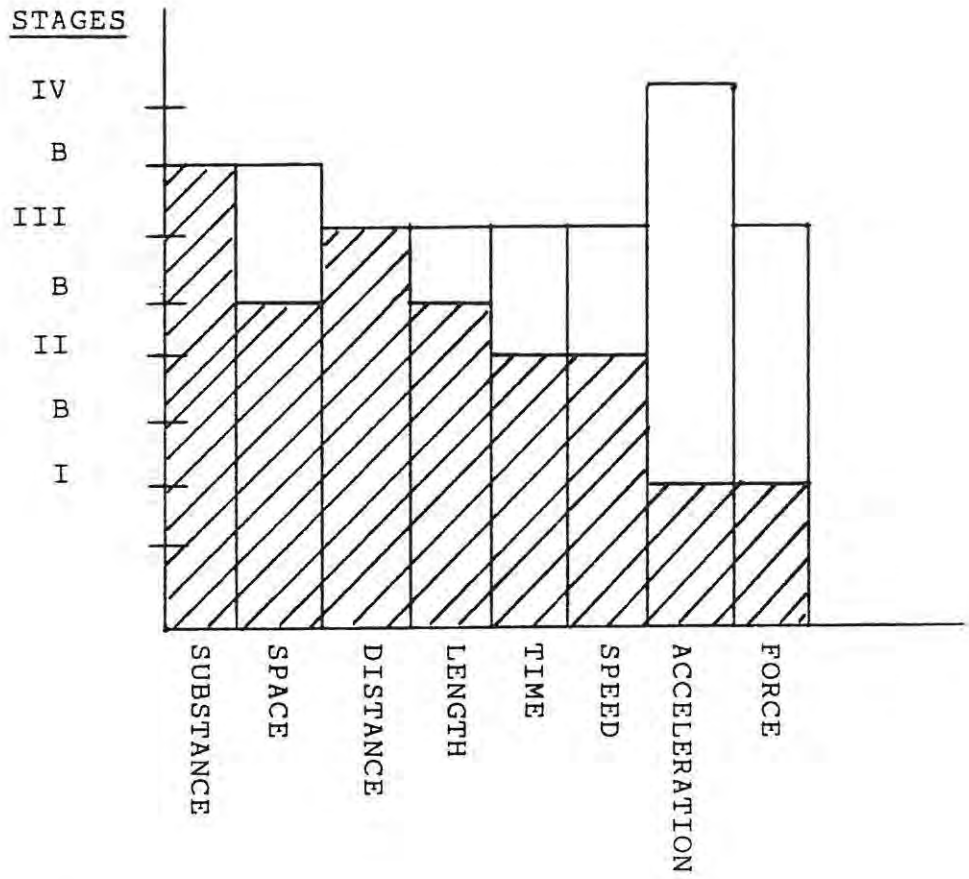
COMMENTS

GLA found thetasks of time, speed and acceleration the most interesting.

This profile reveals evidence of a predominance of pre-operational thinking.

FIGURE 24.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: BUY AGE: 20

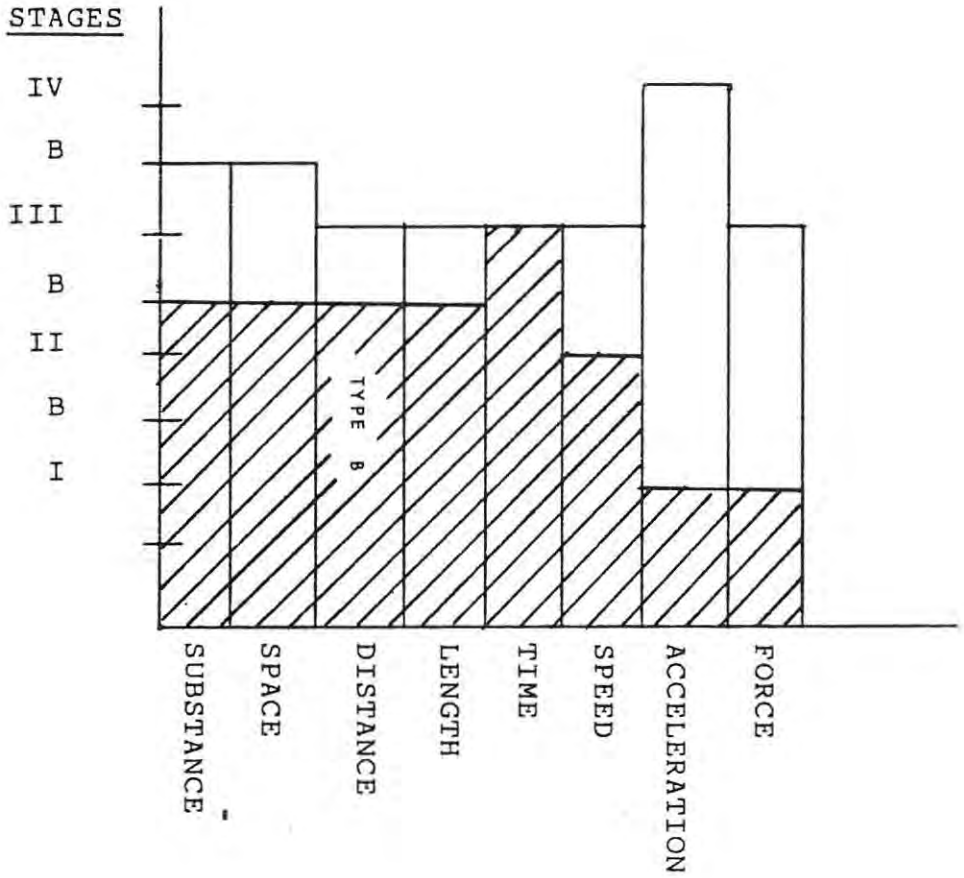
FEMALE BLACK

COMMENTS

BUY found the task of time the most interesting.
She disliked the task of space.
This profile reveals evidence of predominantly pre-operational thinking.

FIGURE 25.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: REB AGE: 17

FEMALE BLACK

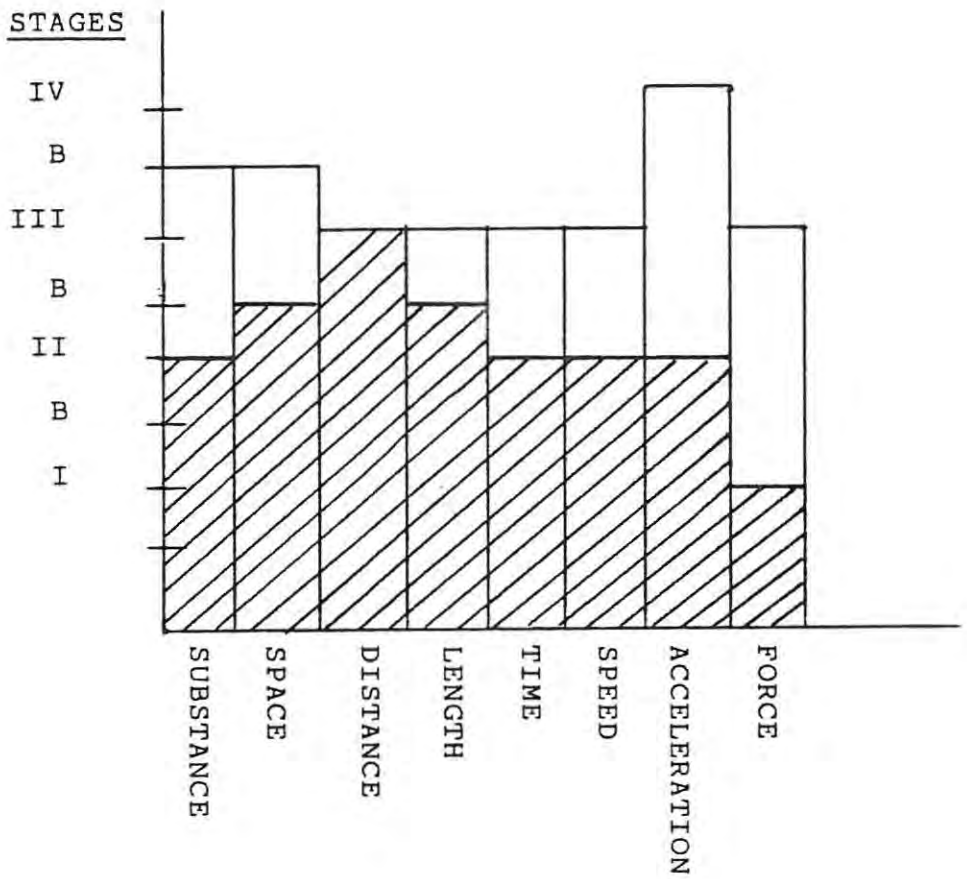
COMMENTS

REB found the task of time the most interesting. She disliked the task of acceleration because it was "too difficult".

This profile reveals a predominance of pre-operational thinking.

FIGURE 26.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: PAU AGE: 8

MALE WHITE

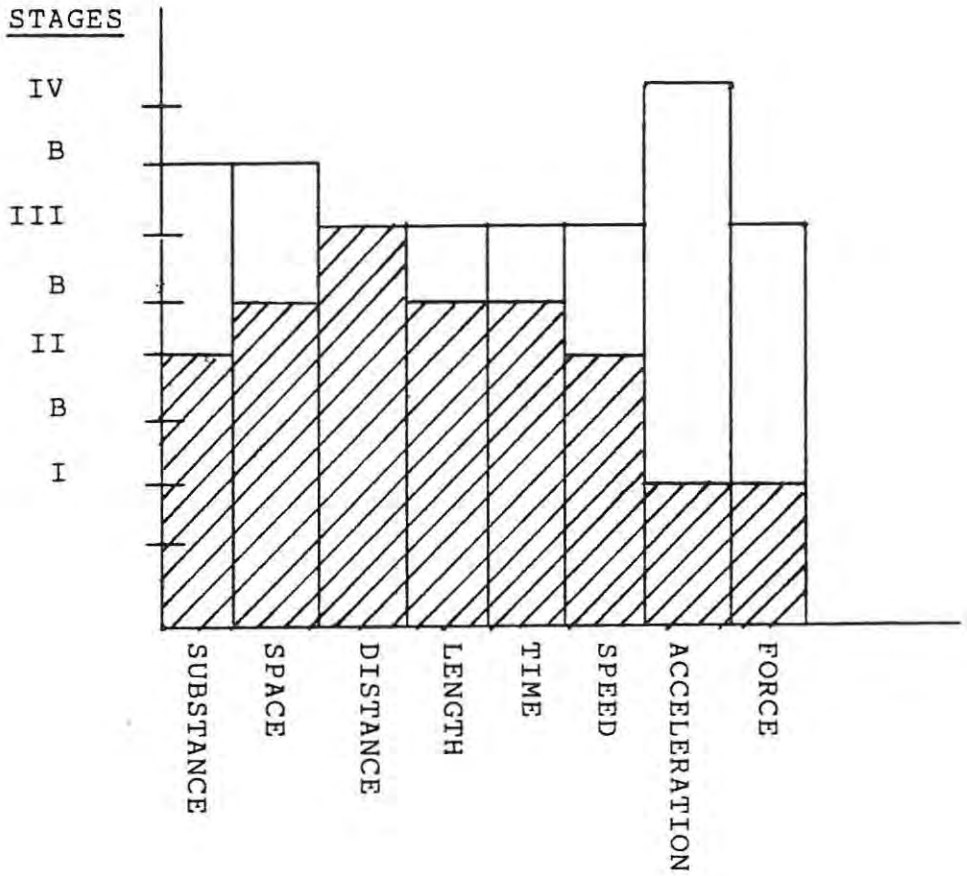
COMMENTS

PAU found the tasks of space, time, speed and acceleration most interesting. He did not like doing the tasks of distance and force.

This profile reveals a predominance of pre-operational thinking.

FIGURE 27.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: SHE AGE: 8

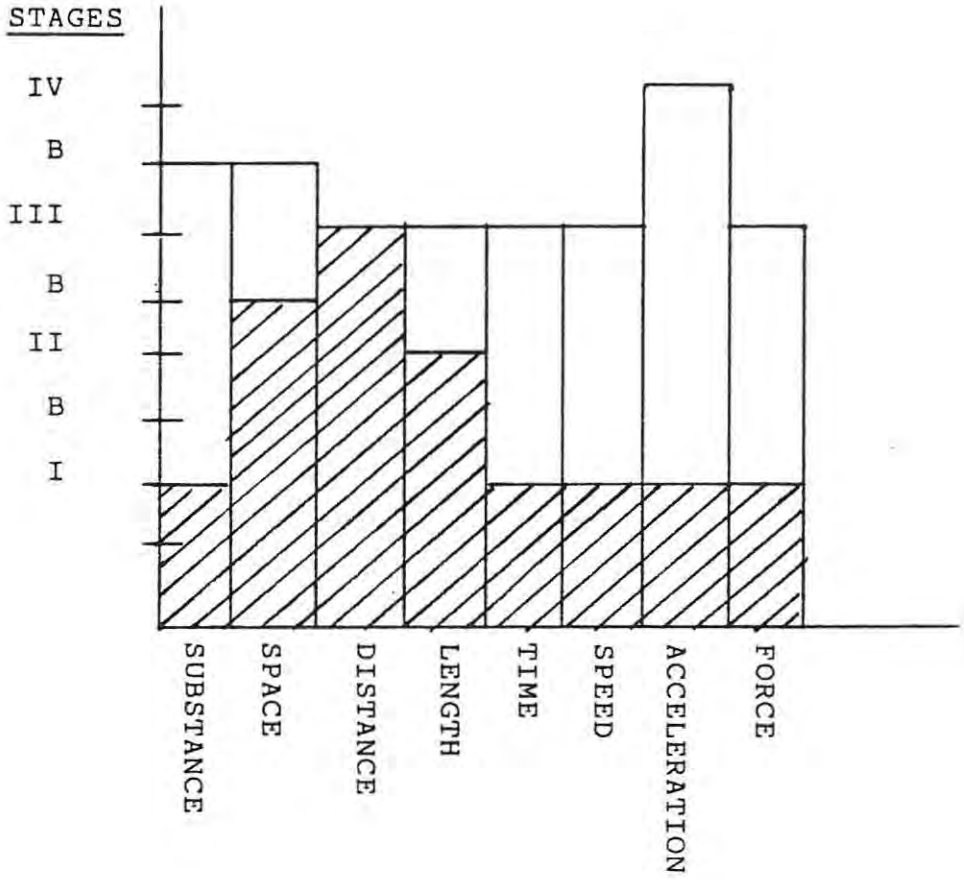
FEMALE WHITE

COMMENTS

SHE found the tasks of distance and time the most interesting. She did not like doing the tasks of speed and acceleration. This profile reveals a predominance of pre-operational thinking.

FIGURE 28.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: DEB AGE: 8

FEMALE WHITE

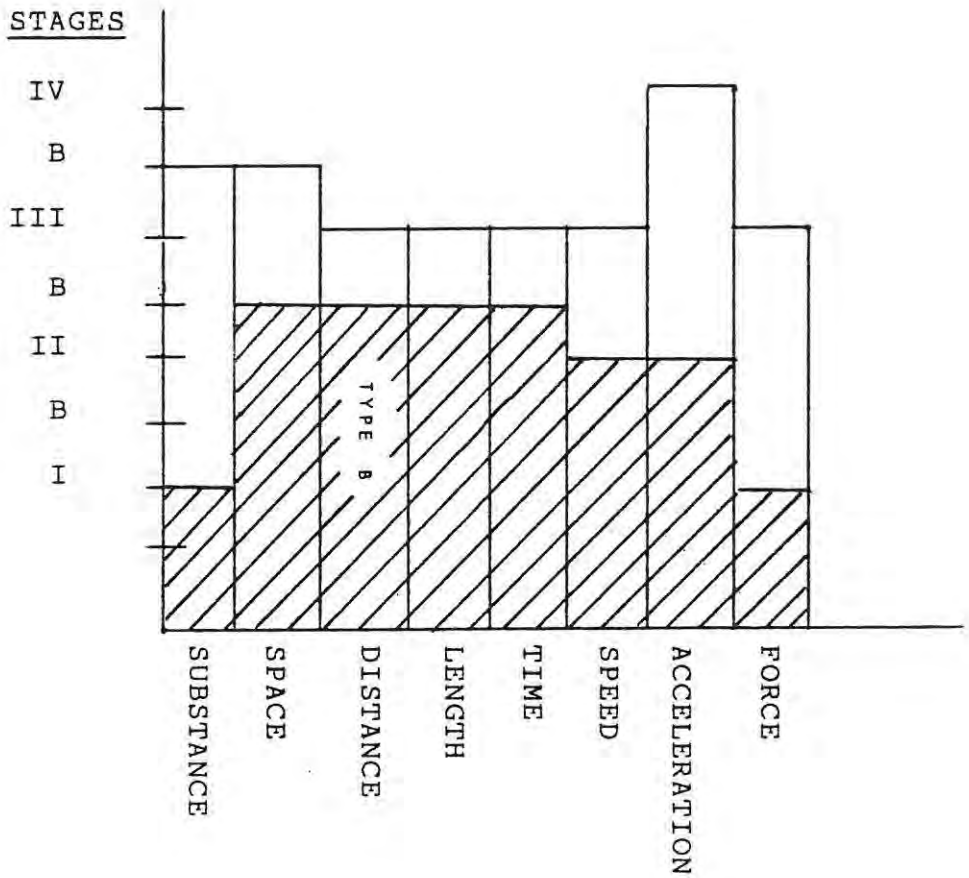
COMMENTS

DEB liked the tasks of space and force and disliked the tasks of substance and time. It would appear that the tasks of time, speed and acceleration had no real conceptual meaning for her.

This profile reveals a predominance of pre-operational thinking.

FIGURE 29.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: MIC AGE: 26

MALE BLACK

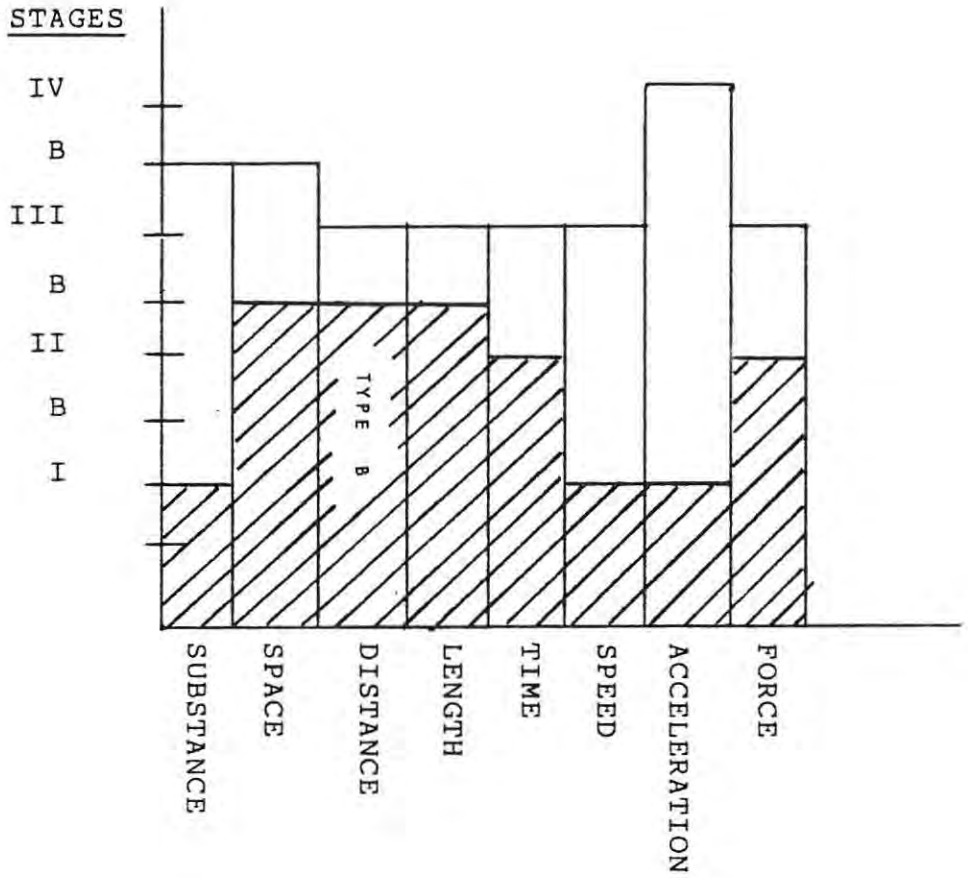
COMMENTS

MIC found the task of space and time the most interesting. He disliked the tasks of speed, acceleration and force because they were "too difficult".

This profile reflects a predominance of pre-operational thinking.

FIGURE 30.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: ERI AGE: 30

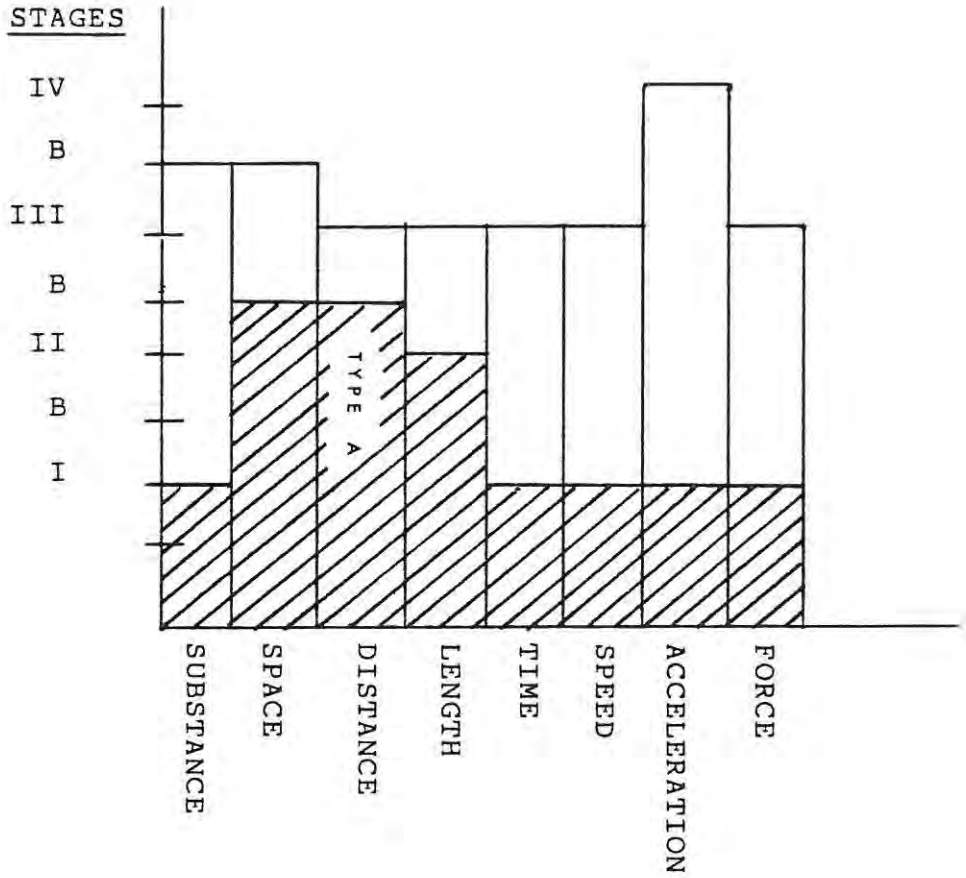
MALE BLACK

COMMENTS

ERI found the concept of force the most interesting. He disliked the tasks of speed and acceleration. This profile reveals a predominance of pre-operational thinking.

FIGURE 31.

PROFILE OF CONCEPTUAL DEVELOPMENT



CONCEPTS

SUBJECT: MIC AGE: 6

MALE WHITE

COMMENTS

It was difficult to find out from MIC which tasks he found most interesting. When asked what tasks he liked doing most, he said those of substance, speed and acceleration. There were none that he disliked.

This profile reveals evidence of pre-operational thinking.

The following table displays a summary of the most advanced area of conceptual development of each subject, with the tasks they liked or disliked; found most interesting or least interesting.

Figure 32 - Summary of development and interests

Name	Most advanced area	Interests/Likes	Disinterests/ Dislikes
Formal operations:			
WIN	Acceleration : Force	Acceleration : Force	Substance Distance : Time
ROB	Acceleration : Force	Acceleration : Force	Substance : Space : Distance and length
DWI	Acceleration : Force	Time : Accelera-tion : Force	--
CHE	Acceleration :	Acceleration : Force	Substance and length
Concrete operations:			
GAV	Speed	Space : Acceleration	Substance : Distance : Length : Time
BES	Speed	Acceleration : Force	--
JEN	Speed	Acceleration : Force	Substance : Length

.../JOA

JOA	Speed	Acceleration : Force	Distance
ROR	Time	Time	--
LIN	Time	Time	Force

Pre-operations:

FOR	Length	Space : Time	Force (because 'too difficult')
BEL	Length	Time	Acceleration : Force (because 'too difficult')
HEA	Length	Space	Speed : Acceleration (because 'too difficult')
ELS	Length	Speed	Space
GLA	Length	Time : Speed : Acceleration	--
BUY	Distance	Time	Space
REB	Time	Time	Acceleration (because 'too difficult')
PAU	Distance	Space :Time : Speed : Acceleration	Distance : Force
SHE	Distance	Distance : Time	Speed : Acceleration
DEB	Distance	Space : Force	Substance : Time
MIC	Time	Space : Time	Speed : Acceleration : Force (because 'too difficult').

ERI	Length	Force	Speed : Acceleration
MIC	Distance	Substance : Speed : Acceleration	--

4.10. DISCUSSION

As this is not an empirical analysis no general statements can be made. However, the results of the pilot study appear to reveal the existence of an exciting relationship between functional interests and the most advanced areas of an individual's conceptual profile. This relationship appears to be far more complex than that previously described (c.f. p. 86). In other words, there does not appear to be a simple direct relationship of functional interests to the most advanced area of the conceptual profile (the most advanced area of the conceptual profile is taken to be that with the highest stage of development. Thus if a subject enjoys stage III development in the concepts of length and time, and stage I development in speed, acceleration and force; the most advanced area of development is in the concept of time). On the other hand it appears that functional interests are to be found coinciding with the area immediately to the right of the concept in which the individual is most advanced.

This cannot be seen clearly with those subjects whose profiles are fully developed - although they would still appear to support this relationship in that they all

.../found

found the tasks of acceleration and force to be the most interesting, whilst the simpler tasks, such as substance, space, distance etc., to be the most boring - but can be seen in most of the profiles revealing concrete and pre-operational thinking. For example JEN (figure 13) is most advanced in the concept of speed and she found the tasks of acceleration and force (in that order) to be the most interesting with substance and length the least interesting.

This does not deny that subjects can have interests in areas to the left of that area in which they are most advanced. Take for example POR (figure 17) who is most advanced in the concept of length. She found the tasks of space and time to be the most interesting. Space is to the left of the concept of length on the conceptual profile, whilst time is to the immediate right. On analysis of her profile it can be seen that she is at stage IIB in the concept of space - the stage immediately prior to the realisation of equilibration and concrete operations in that area - thus it can be said that she is still advancing in that area, striving for equilibration, and is consequently interested in that conceptual area. Theoretically it could be said that POR has a functional interest in space because

.../until

until she advances in that area towards the realisation of concrete operations, she cannot make any significant advancement in the more complex areas of speed, acceleration and force, even though she is interested and advancing in the concept of time. Also to be noted is that POR, like most of the other pre-operational thinkers disliked those tasks that were too far to the right of the area in which they were most advanced. POR said that she did not like the task of force because it was "too difficult". This returns us to the points made by Phillips (c.f. p. 26) that an individual will only be motivated (and thus be interested) in getting to grips with a concept if there is an optimal discrepancy between the conflict (c.f. Smedslund p. 25) of the environmental inputs and the individual's cognitive structures. Thus if the information is too far in advance of the assimilatory/accomodatory capacity of the individual, the result is that the subject becomes frustrated (c.f. Stephens p. 92), or totally ignores the information.

From the results it appears that five subjects (ELS, figure 20; PAU, figure 25; DEB, figure 27; ERI, figure 29; MIC, figure 30) do not support the theoretical model as well as other subjects.

.../ELS

ELS is most advanced in the concept of length, and found the task of speed to be the most interesting, the task of space the least interesting, with no mention being given to the task of time. It may be possible that ELS is interpreting what is most/least interesting here in terms of the physical appearance and attractiveness of the tasks, which can be seen more clearly with the very young subjects (PAU, DEB, MIC), rather than in terms of how cognitively stimulating they are. However, it is to be noted that her interest in the concept of speed still lies to the right of her most advanced area.

PAU is most advanced in the concept of length and found the tasks of space, time, speed and acceleration interesting and the tasks of distance and force uninteresting. His interest in space and time are acceptable in terms of what has been said previously, but speed and acceleration would appear to be too much to the right of his most advanced area, and at the same time, he does not show any great advancement in these particular concepts. The explanation for his interests in these tasks is probably similar to that given for ELS - PAU is a white 8 year old boy who possibly owns some toy cars - thus it may be the toy cars in the tasks of speed and accele-

.../ration

ration that he finds attractive and interesting and not the concepts themselves. A similar case could be occuring with MIC, age 6.

A similar argument could be offered for DEB who found the task of force interesting. To be noted here is that she disliked the task of substance with her justification being 'we don't play with plasticine in standard one anymore. We played with it only in sub-A'.

Looking at the responses of these very young children to ideas such as 'interesting/uninteresting, like/dislike it may be more beneficial, for any empirical investigation of the relationship of functional interests, to work with more mature subjects (e.g. from the age of 12 years upwards) in an attempt to ensure that subjects do not interpret ideas such as 'interesting/uninteresting' in terms of the physical appearance of the task. Furthermore, instead of merely asking subjects which tasks they found interesting/uninteresting, they could be given a formal questionnaire of high validity and reliability that could tap their interests, likes and dislikes more effectively.

ERI offers a different case. His most advanced area of development lies in the concept of length although he found the task of force to be the most interesting. However, an analysis of his conceptual profile reveals that his development in the concept of force as compared with speed and acceleration is quite high. Thus just as other subjects who show conceptual shortfalls to the left of their most advanced area and have interests there, it may also work in the opposite direction, as with ERI, where there is a relatively high development in an area far to the right of the most advanced area and where functional interests also flourish. However, in terms of the proposed theory of the conceptual profile, it is expected that ERI would not be able to make any further significant advances in the concept of force until he has advanced in those conceptual areas to the left of the concept of force, i.e. time, speed and acceleration, and he would possible have to transfer his interests to focus more on those tasks to the immediate right of his most advanced conceptual area.

It is interesting to note that many of the young black subjects revealed more developed conceptual profiles than the older mature black subjects. This returns to the point made by Page (c.f. p. 65) and the role of

.../education

education in the promotion of cognitive development, and more directly to Russell's focus on the relationship of the conceptual system to cognitive development. The conceptual system surrounding the black youth today can be seen as different in many ways (particularly in the areas of industrial and technological exposure), to the conceptual system that surrounded the mature blacks in their youth.

An analysis of the conceptual profiles reveals that the battery appears to be tapping individual uniqueness in cognitive development. Consequently, the battery of tasks not only holds value as a diagnostic tool or as a remedial training programme, it could possibly be used as a method of selection. Piaget offers so many varied tasks dealing with many conceptual areas that a battery of tasks could be constructed covering those conceptual areas that are required for an individual to perform a job or complete a task successfully. What would be required to build such a battery is not a job description in the traditional form of the level of decisions that have to be made, but a job description defining the cognitive operations involved. Once this is achieved, it is then a simple matter of putting together a particular number of Piagetian tasks that

.../cover

cover the most simple and the most complex cognitive operations and conceptual areas. The result would be to identify individuals with cognitive ability to handle a particular job or task, rather than potential I.Q's and vaguely defined aptitudes. More importantly, a Piagetian battery used for any selection process is possibly the best way of selecting accurately in the cross-cultural interface. (Consider for example, the use of such a battery in the selection of black team leaders in underground mining gangs who, to ensure safety in working conditions, will require a certain understanding of scientific concepts).

4.10.1. ADVANTAGES OF THE PROPOSED DIAGNOSTIC PROGRAMME

The use of Piagetian tasks in a battery as a diagnostic tool, a remedial training programme and a potential selection process holds various advantages:

1) It stresses and caters for individual differences in cognitive development.

2) It is a diagnostic process that allows for the realization of problem areas (as well as positive areas) in an individual's conceptual development at a point in time.

.../3)

3) It enables a realization of how a remedial programme should be designed, where it should begin and with what concepts, in such a way as to meet individual needs.

4) It operates on a purely voluntary basis and can facilitate self-development by guiding the individual into those areas that require development.

5) It attempts to make optimum use of individual interests thus maintaining motivation.

6) The emphasis remains on the creation of cognitive structures and operational thinking - a focus on understanding as opposed to learning.

7) It aims at non-specific transfer and development in all conceptual areas.

8) By developing cognitive structures within a concept such as force, development may be allowed to begin in other complex areas such as heat, light, electricity etc.

.../9)

9) Once cognitive structures are 'equilibrated' they are lasting. No retraining or developmental programme is needed to cover similar groups again.

10) The developmental process once encouraged has no end as the individual continuously uses what he has gained to get to grips with more complex concepts.

11) It can adequately cope with the cross-cultural interface where other tools must be standardised and validated, and often changed in format and appearance.

4.10.2. DISADVANTAGES:

1) Time is a significant disadvantage. For the present diagnostic battery, interviews averaged 40 minutes in duration. Obviously the more tasks there are in a battery, the longer the interview will take.

2) Only one individual can be interviewed by a facilitator at a time. As this programme

.../is

is orientated towards meeting the needs of the individual, it could not be adequately administered to groups.

3) The interviews can only be conducted and interpreted by a facilitator who has intimate knowledge of Piagetian theory and practise, in order to get accurate information and consequently develop reliable and valid conceptual profiles.

4.11. CONCLUSION

This pilot study has revealed certain valuable hypotheses in regard to the relationship of functional interests and the most advanced areas of development within an individual's conceptual profile. These are:

1) A battery of Piagetian tasks revolving around a complex scientific concept can reveal a unique profile of an individual's conceptual development.

2) Functional interests are related to conceptual development in that they generally

.../appear

appear to coincide with the next more complex concept to that in which the individual is most advanced, particularly if the individual has reached operational thinking in his most advanced area. It may be said that functional interests transcend that conceptual area in which the individual is most advanced, towards development in the next most complex conceptual area.

3) Functional interests may also be found to coincide with those conceptual areas in which the individual is not fully developed, but are at the same time more simple than that concept within which he is most advanced.

Overall, these hypotheses point towards the need for an exhaustive empirical investigation of the relationship between functional interests and conceptual development, and the realization of a tighter body of theory that can adequately account for this intimate relationship.

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