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A RELATIONSHIP BETWEEN SUCCESSIVE-SIMULTANEOUS SYNTHESIS AND CONCRETE OPERATIONAL THOUGHT

by

TUNTUFYE S. MWAMWENDA

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled A Relationship Between Successive-Simultaneous Synthesis and Concrete Operational Thought submitted by Tuntufye S. Mwamwenda in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Supervisor

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Date Nov 17, 1980

ABSTRACT

The primary purpose of this study was to investigate a relationship between Das' model of information processing and Piaget's theory of cognitive development. Specifically, it was hypothesized that simultaneous processors would outperform successive processors on concrete operational tasks, namely, class inclusion, transitive inference, and conservation of liquid. Secondly, it was hypothesized that those who would be high in both simultaneous and successive synthesis would outperform those who would be low in both strategies. Thirdly, it was predicted that older subjects would perform on Piagetian tasks significantly better than younger subjects. Similarly, it was predicted that older subjects would outperform younger subjects in simultaneous synthesis skills. All four hypotheses were strongly supported (alpha 0.001).

The sample consisted of 178 subjects, ninety-four of whom were males. These were sixty kindergarteners, sixty grade ones and fifty-eight grade twos selected from four randomly chosen schools from the Edmonton Separate School Board. Their mean ages were: kindergarteners 5.4 years, grade ones 6.5 years, and grade twos 7.3 years. The grand mean age for the total sample was 6.3 years.

Four tests were used for measuring simultaneous and successive synthesis. These were Raven's Progressive Matrices, Figure Copying (for simultaneous synthesis), Digit Span and Serial Recall (for successive synthesis). Three tests were used for assessing concrete operational thought involving class inclusion, transitive inference, and conservation of liquid concepts. For class inclusion, sets of plastic animals (horses and cows) and plastic fruits (apples and bananas) were used. Two sets of sticks labelled A, B, C were used for the assessment of transitive inference. In assessing conservation concept, three beakers and two bottles filled with water were used as apparatus.

In conclusion, it was argued that since a strong relationship was observed between Das' model and Piaget's theory, and in view of the fact that both simultaneous and successive synthesis as strategies are susceptible to training, a study should be carried out in which predominantly successive processors would be trained to process information simultaneously. Following this, the subjects would be retested on Piagetian tasks to determine the impact of such training.

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Chapter I

INTRODUCTION

It is generally agreed that most reaearchers are more concerned with the content aspect of cognitive development than the process involved in achieving it (Brainerd, 1978; Bruner, 1975). The purpose of this study, therefore, was to examine the process involved in successful performance on Piagetian tasks and how it matches Das' model of simultaneous-successive synthesis.

Estes (1974) has argued that the learning process should be examined instead of concentrating on product-oriented methods of measuring intelligence; he is in favour of characterizing intelligence as a learning process. Similarly, Siegel (1978) points out that the nonverbal approach should be taken in the light of a learning process rather than the presence or absence of cognitive structures.. In case of a young child, she argues, nonverbal measures emerge as more appropriate to a process rather than a product-oriented approach. In a similar vein, Bruner (1975) contends that developmental psychologists have concentrated too long and too hard on the problem of what a child cannot do at certain stages instead of raising the more important questions of the type of capacities they use, and how instruction can take advantage of these processes or capacities. Commenting on transitive inference, Youniss (1975) notes:

> In the current literature, there is a strong trend to look more closely at the person's ways of processing information to reach logical conclusions.

Flavell (1977) holds that for psychologists to fully understand the course of cognitive development, it is essential that they examine the process involved. He implies that the content-oriented approach so often used in Piagetian traditional approach may be inadequate. In a similar train of thought, Collyer and Thayer (1978) suggest that future diagnostic research on transitive inference should be primarily process-oriented. In reference to individual differences, it is generally accepted that studies in the past have failed to identify cognitive abilities responsible for such differences (e.g. McNemar, 1964; Ferguson, 1965; Green, 1968; Bouchard, 1968). Thus McNemar (1964) states:

> These studies of individual differences never come to grips with the process or operation by which a given organism achieves an intellectual response (1964, p. 881).

This is further reflected in Piaget's (1964) argument that nonconcrete operational children's poor performance in classification is due to the fact that they base their responses on step-by-step basis, whereas classification calls for coding information successively, but more importantly, it is essential that a subject should be able to see a number of relations among the given objects. This will facilitate his coordinating objects hierarchically and multiplicatively which is basic for his successful performance. Such a process would require the subject to process information simultaneously rather than successively.

It may be further argued that the child's ability to deal with class inclusion requires that he be able to discern subclasses from two points of view: one as classes in their own right and secondly, he should be able to view them as members of the same class as shown in this equation $A+A' \rightleftarrows B$. This would indicate that the concrete child is capable of thinking of the parts as discrete from the whole and the whole simultaneously. In examining A and A', he bears in mind the relationship they share or hold with the supraordinate class B. Commenting on the cause for subjects' poor performance in class inclusion, Thayer and Collyer (1978) remark:

> It appears that younger children seem to have more difficulty in successfully completing some tasks that include relations of equality between some stimulus terms or that require an active discovery of the initial premise relations (p. 1334).

The key message in this quotation is the subject's failure to see relations between a given number of objects. The same argument could be extended to anyone who has problems with class inclusion, that unless the subject is able to see the given or implied relations, his performance is not likely to be satisfactory. The ability to see such relations is very much part of simultaneous synthesis (Das et al., 1975). Moreover, Riley (1976) holds that there exists a developmental effect in the performance of Piagetian class inclusion tasks, whereby to begin with, children use linear orders in representing relationships based on physical or spatial dimension prior to their using them for relationship in the absence of such concrete properties. Basing their argument on Riley's (1976) work, Thayer and Collyer appropriately state:

> ...experiments provide support for the idea that children prefer to represent a set of premises in an ordered sequence of terms, even when the task presentation is intended to force the use of deductive reasoning. (p. 1340)

While the use of sequential ordering cannot be ruled out in deductive reasoning, it is not sufficient to lead to logical conclusions; hence the rationale for children's poor performance in class inclusion tasks. In passing, the authors note (Thayer and Collyer, 1978, p.): "...although we speak of deductive reasoning as a theoretical alternative to linear ordering, at this point there does not yet seem to be a process model with which to identify this alternative". It is proposed here that Luria's (1966) and Das' model (1971, 1973) of information processing can serve as Thayer and Collyer's process model. The alternative for which they fail to find a model could be simultaneous synthesis and the linear ordering fits, it would seem, Das' successive synthesis.

In a similar trend of thought, Wilkinson (1976) argues that poor performance in class inclusion could be due to the subject's strategy which interferes with what the experimenter expects him to do. It is pointed out that the child arranges, in class inclusion, the different objects by means of counting so that his grouping would be based on what he has counted and what he has yet to count. The problem with such a strategy is that once the counting has occurred, the chances of re-examining the material is eliminated. The nature of class inclusion seems susceptible to such a procedure, e.g. "Which are more the flowers or the roses?" If the roses have been counted, the child may see no need to recount them. The process described fits well with Das' successive processing and the process implicitly recommended matches Das' simultaneous processing which entails both the counting aspect and going back and forth establishing relationships between the various aspects of objects.

A similar type of problem emerges in Piaget's (1957) outline of the strategies used at arriving at an operational notion of conservation: First, the child attends to one dimension, but not two (length or width); such a subject is not likely to conserve. Secondly, the subject centrates on one dimension of an object and substitutes a series of centrations on the other dimension, while ignoring the first centrated dimension. In Wilkinson's vein of reasoning, the child feels that he has accounted for the first centrated dimension and as such, he sees no need of attempting to relate it to subsequent tasks. In this process, it would appear that he is in fact using a successive mode of information processing instead of simultaneous synthesis which demands both his taking into consideration what has been accounted for as well as the relationship existing between the accounted for and subsequent information.

Commenting on sensory intelligence in contrast to representational thought, Piaget (1941, 1950a, & 1954a) further argues that motor intelligence is capable of only linking in a sequential order successive actions or perceptual states with which the child may be dealing. To use Piaget's illustration, it is like a slow-motion film in which static frames are represented in succession without displaying a simultaneous and all-encompassing purview of all the frames. Representational thought, on the other hand, is capable of achieving a simultaneous grasp of the whole. In a single brief moment, Piaget continues, representational thought is capable of recalling the past, representing the present and simultaneously anticipating the future. In passing, it is relevantly significant to note that the process involved in representational thought is typical of what holds true in Das' (1979) description of simultaneous synthesis.

For clarification, further information on Das' model may be in order. Briefly, Das et al (1979) postulate that successive and simultaneous synthesis is a construct of individual differences in processing information. The simultaneous component processes individual pieces of information into simultaneous groups; the successive component processes discrete information into successive series. While simultaneous synthesis involves the integration of successive stimuli into a single surveyable simultaneous group, successive synthesis entails an integration of a series of elements, the total of which may not be surveyable as a single whole. The Details of Das' model of information processing will be given in a separate chapter. It suffices for now to bear in mind that the distinction between the two processes is that simultaneous synthesis involves one's ability to see individual parts of a whole and then relate them to various aspects of that whole or other related or unrelated parts. The successive synthesis mode involves one's ability to see individual parts of a whole, but without being able to effectively relate them to the whole. It is very much like Witkin's theory of psychological differentiation in that field dependents see objects globally, whereas field independents are able to see objects both globally and analytically. The relationship between Witkin's theory and Das' model has been investigated and reported (Heemsbergen, 1979).

In view of the process involved and required in concrete operational thought, it does not seem unreasonable to expect that a person who predominantly processes information simultaneously would perform better on Piagetian tasks than a person who processes successively. Conversely, poor performance on Piagetian tasks could be due to one's excessive or predominant use of successive synthesis.

Given the similarity between the processes required in concrete operational thought and Das' model, it was evident that the two constructs or theories were related. This conceptual relationship served as the rationale for the current study to determine whether or not the conceptual relationship observed could in fact be empirically supported. As a primary hypothesis, it was predicted that those who were high in simultaneous synthesis would perform significantly better in concrete operational tasks than those who were high in successive synthesis. Secondly, it was hypothesized that those who were high in both simultaneous and successive synthesis would outperform those who were low in both modes in the three Piagetian tasks, namely, conservation of liquid, transitive inference, and class inclusion. There were other hypotheses, but these did not pertain to the relationship between the two theories.

This study is divided into eight chapters. The first chapter supplies the rationale for undertaking this study as well as the underlying reasons for assuming that Das' model could serve as a parsimonious device for explaining performance on Piagetian concrete operational tasks. In chapter II, the nature of simultaneous and successive synthesis is examined in the light of psychoneurological findings by Luria (1966) and Das' model based on factor analysis (Das, 1973).

Chapter III focusses on three concrete operational tasks, namely, conservation, transitive inference, and class inclusion. The fourth chapter examines Das' model in light of other information processing models. These models are also examined in the light of Piaget's theory. In view of the surveyed evidence, it was syllogistically concluded that some conceptual relationship exists between Das' model and concrete operational thought. This is followed by statement of problem and research hypotheses. The sixth chapter is a description of the research design; covering the sample, measuring instruments, and procedure used for the collection of data. In chapter seven, the analysis of data is presented, and is followed by a discussion which is the focus of chapter eight.

Chapter II

SUCCESSIVE AND SIMULTANEOUS SYNTHESIS

The focus of this chapter is on the strategies used in the processing of information. The author first examines these processes as understood by Soviet psychologists (e.g. Sechenov, 1878; Luria, 1966). This is followed by a description of Das' model as an extension of Luria's work.

Luria, a neuropsychologist, has identified two forms of integrative activity of the cerebral cortex, namely, successive and simultaneous synthesis. Different parts of the cortex specialize in one of the two processes: simultaneous and successive. The two parts of the cortex concerned with information processing are the occipital parietal cortex, and the temporal cortex. The former is associated with simultaneous synthesis and is used for integrating individual stimuli in simultaneous groups, whereas the latter is associated with successive synthesis and is used for integrating individual stimuli in a sequential order as they are received by the human brain (Luria, 1966). Though the different parts of cortex may be engaged in both forms of synthesis activity, Sechenov (1878) argues, one of them is likely to be more active than another.

Each one of these two major processes will be examined in detail:

Simultaneous Processing

Simultaneous processing synthesis, Luria (1966) points out, assumes its role under various situations. For example, it may take place during direct perception, during retention of traces of previous experience, or when the subject is engaged in a task that calls for complex intellectual operations. On this basis, Luria (1966) refers to the three phases of information processing as perceptual, mnestic and intellectual levels of simultaneous synthesis.

As an illustration, Luria points out that when a picture is exposed to a subject's attention, it is seen as a whole and it is only after being examined thoroughly that its parts are perceived and then synthesized into a single entity as a unified visual structure (Luria, 1966, p. 75). He also argues that visual perception entails a double series of processes which are a system of movement of the eyes. The two systems join together to form the activity of exploration of different individual stimuli which leads to a formation of an integrated image of a given object. A similar process is repeated when an object is felt by the hand; the difference being that, the individual signs of an object are identified without being related to the whole, and only after this preliminary has occurred is simultaneous scheme composed.

Simultaneous processes also are involved in acoustic analyzers: when a person hears, he distinguishes timbre and pitch relationships, rhythms and accents as well as simultaneous associations of sounds or chords. It is also true that hearing often relates a sound to a certain point in space, thus incorporating the stimuli into some form of spatial relationships.

To summarize, it is important to note that a person's ability to synthesize elements into whole simultaneous groups is an important factor in complex intellectual processes, since one's understanding of relationships is dependent to a great extent on the synthesis of elements into a simultaneous surveyable organization.

Successive Processing

While simultaneous synthesis involves the integration of successive stimuli into a single surveyable simultaneous group; successive synthesis entails an integration of a series of elements, the total of which may not be surveyable as a single whole (Luria, 1966).

Successive synthesis, like simultaneous synthesis, operates at different phases such as sensorimotor, mnestic and intellectual processes (Luria, 1966). The following examples illustrate the process: rhythmic or tonal melodies which are organized on the basis of their time of occurrence; different forms of movements such as writing: the first movement sets in motion a series of movements that follow each other sequentially. It must be borne in mind, nevertheless, that the described forms are not subject to surveyability.

Luria's claim regarding the existence and nature of the two processes were supported by extensive and intensive research involving subjects who had lesions either in the parietal-occipital part of the cortex or the fronto-temporal part of the cortex. These observations will be described under the two processes: simultaneous and successive synthesis. Their detail description is desirable because they throw further light on the implication and nature of the two processes.

Disturbance of Simultaneous Synthesis:

As a result of lesions of the occipital -parietal parts of the brain, there is considerable disturbance of the synthesis of stimuli into simultaneous groups. This may be observed at different levels of mental activity and spheres. People who have a lesion of the occipital-parietal region in the left hemisphere testify that, although they are able to grasp individual components of an object or situation, they find themselves totally at a loss in attempting to comprehend such a situation in totality. In reading, for example, words have to be read letter by letter rather than as complete words. This indicates very strongly the patient's inability to form successively presented stimuli into a simultaneously perceived structure. Similarly, a disturbance of simultaneous synthesis in the tactile sphere may lead to a person's inability to compose together details of stimuli involving the sense of touch.

When a lesion is located in the inferior parietal region where it has a common border with the occipital region, the subject experiences a loss of the spatial organization of perceived elements (Luria, 1966). Patients with such a problem are unable to trace the direction of their path; they easily lose their way when moving from one room to another; they have difficulty in arranging clothes or other objects in their proper order. Luria (1966) further notes that such patients are unable to reproduce symmetry figures for as far as they are concerned, they do not see any distinction; they are unable to reproduce from memory geometrical figures, nor are they able to write the alphabetical letters correctly.

In map reading, they confuse the east with the west and the various locations on the map are placed randomly. It is further noted (Luria, 1966) that apart from sensorimotor and perceptual disturbance of parieto-temporal region, a similar disturbance may be observed at the higher level of ~~mental~~ activity which may affect the logico-grammatical as well as arithmetical operations. While patients may understand every day-speech, they are unable to comprehend logico-grammar which is laden with simultaneous integration of its various components. For example, they would not distinguish between the phrases "the father's brother" and "the brother's father" or "a triangle below a cross" and "a cross below a triangle". If the subject is asked to draw what he has been told, he will do so in the order in which they are mentioned rather than in the form of their meaning. They are also at a loss to figure out complex constructions which express comparative relationships and inversions of meanings.

They are also weak at comprehending ideas of numbers and arithmetic operation (Luria, 1961). They may perceive the quantity of numbers, but will not be able to produce them in their categorical structure, e.g. 1029 may be reproduced as 129 or 1000 29. It has been further shown that they have difficulty reading multiple digits or fractions or solving problems involving such figures. The situation is aggravated, when the subjects are required by the nature of the task to depend on an internal recognition of numerical relationships.

It is interesting to note, however, that successive syntheses of such patients remains relatively unaffected. Patients are able to reproduce rhythmic structures without being able to synthesize them into a whole (Semernitshaya, 1945).

Successive mnestic syntheses, too, remains unaffected so that patients are able to repeat series of words without altering the order in which they are given. In the area of speech, no defect is manifested, unlike those who have lesions of the fronto-temporal.

Disturbance of the simultaneous syntheses in lesions of posterior occipito-parietal is evidenced by a malfunction in visual perception. On the other hand, their ability to deal with logico-grammatical and arithmetical operations is not affected. These operations, however, may be affected when lesions are located in the parieto-occipital or parieto-fronto-occipital systems.

Disturbance of Successive Synthesis

Both the frontal and fronto-temporal systems are part of the cortical sections of the motor and acoustic analysers. Their main function is to analyze stimuli that are separated from each other on the basis of their time of occurrence and then the subject composes them into successive series (Luria, 1966). Lashley (1960) suggests that the basic function of these areas of the brain focusses on temporal, serial organization of processes. Consequently, a lesion in these parts leads to a malfunction of the synthesis of elements into successive serially organized groups.

The posterior frontal or the superior divisions of the premotor are connected with the functioning and organization of limb movements, whereas the inferior areas of the left hemisphere are responsible for organizing speech movements. Consequently, a disturbance of successive synthesis may lead to an interference with serial organization movements and acoustic and speech processes.

If a subject is asked to draw three or more elements in succession, he experiences difficulty recalling the order in which the elements were given and in many cases, he will keep redrawing the same figure or change their order of presentation. Such a problem is more acute with people who have a lesion of the fronto-temporal system as a result of which they find it relatively hard to retain series of traces of verbal instructions.

Similarly, a lesion in the Broca area leads to inability to articulate individual sounds of words. A disturbance in successive syntheses also leads to a person's inability to recite poetry; instead of reproducing it in a successive single rhythmic melody, the subject may reproduce it in its general meaning.

DAS' MODEL OF SIMULTANEOUS AND SUCCESSIVE SYNTHESIS

By means of factor analysis, Das and his colleagues have extended Luria's work and developed a viable model on which the present study was based.

Das, Kirby, and Jarman (1975, 1979) have argued and demonstrated that successive and simultaneous processes are constructs of individual differences in processing information. In a nutshell, the two components of the model are defined and described as follows:

> Simultaneous integration refers to the synthesis of separate elements into groups. The essential nature of this sort of processing is that any portion of the results is at once surveyable without dependence upon its position in the whole.
>
> In order for the human organism to grasp systems of relationships, it is necessary that the components of the systems be presented simultaneously. In this fashion, the relationships among components can be explored and determined (Das et al., 1975, p. 89).

The second component is defined in a similar fashion:

> Successive information processing refers to processing of information in a serial order. The important distinction between this type of information and simultaneous processing is that in successive processing the system is not totally surveyable at any point in time. Rather, a system of cues consecutively activates the components (Ibid.).

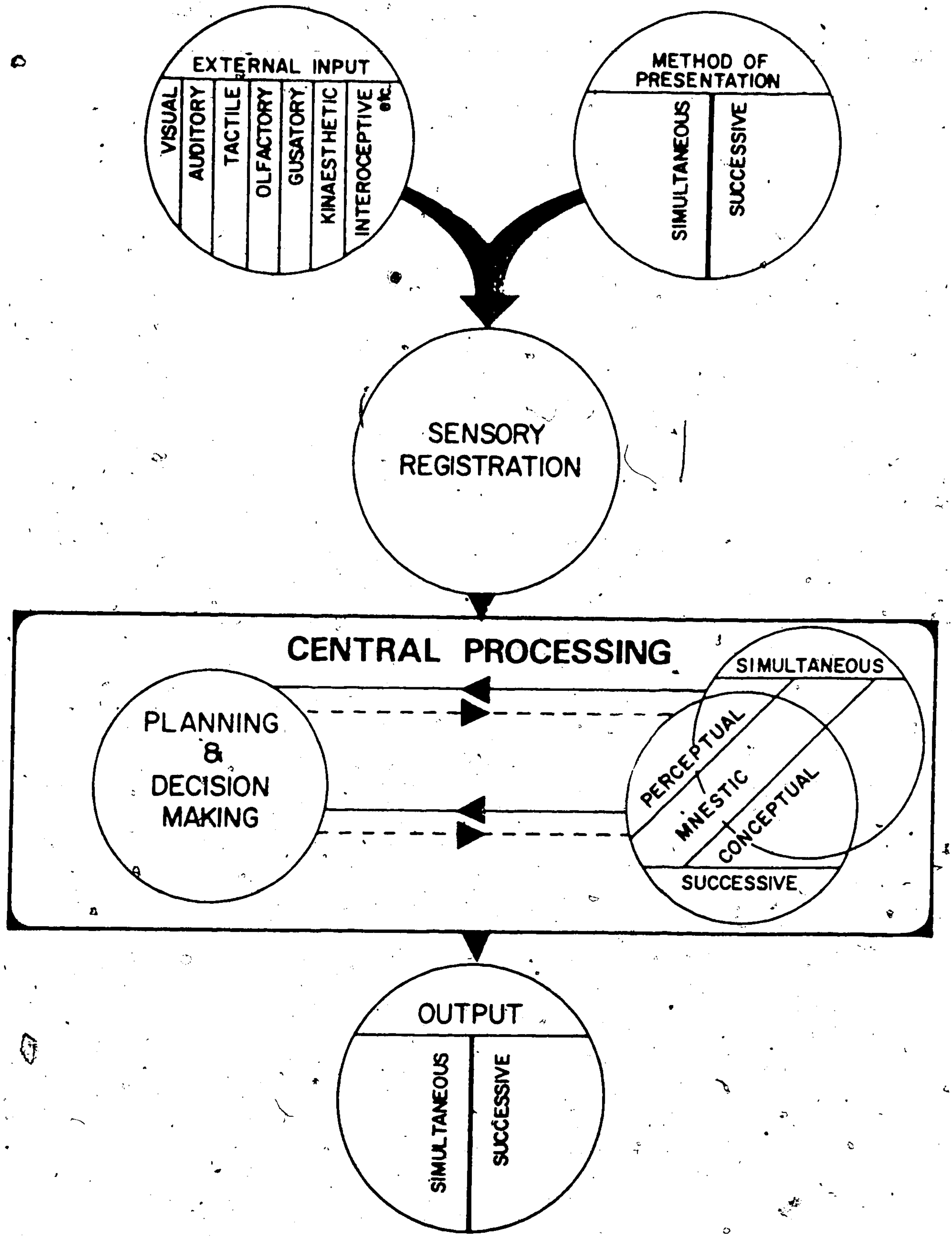
A similar description is advanced by Jarman (1978, p.258) who states:

> Simultaneous synthesis refers to the organization of information into composites, such that the relationship of elements to one another can be determined.
>
> In contrast, successive synthesis is a form of information which does not allow analysis of the relationship of multiple elements to one another. Rather, information is organized in a temporal, sequence-dependent form.

Das (1973) points out that one's likelihood of using either mode is a function of the nature of the task at hand as-well as a function of one's past or cultural experience. Despite the fact that some cultures may prefer using either successive or simultaneous synthesis, Das (1973) argues that the two modes are not hierarchical. This assertion, however, has been challenged (Jarman, et al, 1980).

Information processing according to Das' Model(1975) involves four hypothetical units, namely, the input unit, the sensory register, the central processing unit and the output unit as illustrated in Figure I. At the first stage, the information may be exposed to the subject either successively or simultaneously through one of his sense of modalities such as visual, auditory, olfactory. This information is then passed on to the sensory unit for immediate registration in the sensory register which in turn transmits it to the central processing unit. The central unit consists of three components which may be described on the basis of their functions: the simultaneous component processes individual pieces of information into simultaneous groups; the successive component processes discrete information into successive series, and the decision making and planning component which is responsible for executing the information processed by the other two components as well as the actual directing in the course of information processing. In passing, it is relevant to note (Das et al, 1975) that the sensory input

FIGURE I



INFORMATION INTEGRATION MODEL
(after Das, Kirby & Jarman, 1975)

which may be either successive or simultaneous does not determine the mode of information processing in the central processing unit or in other units of the model.

Empirical Evidence:

Das et al (1975) have empirically demonstrated that successive and simultaneous modes of information processing are relatively stable factors across culture, age achievement levels and SES. In a study of 60 retarded and 60 nonretarded subjects, it was observed that in both groups, the simultaneous factor was defined by the following psychometric measures: the Progressive Matrices, Cross-modal Coding, short-term Visual Memory and the IQ score. Serial and Free Recall of Words tests defined successive processings.

Molloy (1973) demonstrated the universal presence of both successive and simultaneous processing in 6- and 10-year old subjects in which speed emerged as a third factor. To test the stability of these factors across SES, Molloy (1973) administered a group of tests to 60 low SES and 60 middle SES subjects; the three factors emerged across both groups of subjects. In solving Cross modal coding problems, speed and the simultaneous factor were of significant importance to middle SES subjects.

From a cross-cultural stand point (Das, 1973a), the three factors were observed to be relatively stable. The existence of simultaneous and successive synthesis as well as its stability has been borne out by other studies (e.g. Krywaniuk, 1974; Ashman, 1978; Kaufman, 1978; and Bickersteth, 1979). On the other hand, not every research investigation has supported the stability of these modes of information processing (Anderson & Travis, 1979). For example, Jarman (1975) reports that in his investigation, successive processing and speed were less stable across IQ groups. Generally, he elaborates, the three factors were replicated, but only simultaneous synthesis was shown more distinctly than others which were not observed in some of the tests (Jarman, 1975, p. 130-131).

Both Luria (1966) and Das et al (1975) have argued for equal status and functional independence of simultaneous and successive synthesis. Jarman (1978), however, has advanced the argument that there is some evidence to indicate that simultaneous processing may be a superior and more effective means of processing information than successive synthesis. His argument is derived from linguistic studies that have identified two modes of processing language, namely syntagmatic and paradigmatic. The former involves association between words of different grammatical class in a sequential relationship; paradigmatic involves association of words of the same class which can be used substitutetively, e.g. cold/warm.

The linguistic mode of processing information has been shown to be developmental so that before the age of 6 or 9, the child processes information syntagmatically and thereafter switches to a paradigmatic mode (Denney, 1974). Pribram (1958, 1960) and Luria (1973b) have pointed out that paradigmatic processing is generated by simultaneous synthesis, whereas syntagmatic processing is a function of successive synthesis. It follows, therefore, that simultaneous and successive modes may be hierarchical. This would be in direct contradiction with both Das' (1975) and Luria's claim of simultaneous and successive processes being nonhierarchical.

Despite this speculative argument, the hypothesis that there are two modes of processing information remains unchanged. On the other hand, the equality in status of the two modes is open for further investigation. The argument advanced by Jarman (1978) has to be substantiated by direct research on simultaneous and successive synthesis instead of inferring to what might be true in language processing.

Since simultaneous-successive synthesis is a relatively new model to the West (Das et al, 1975), not many psychologists have had the time to examine it rigorously. In view of this, only two criticisms will be reported here. Ryba, Vernon and Lang (1978) have observed that due to verbal loading on Das' tests, they show close similarity, thus tending to yield a spurious factor. This spurious factor, they further argue, is what provides the basis for Das' model of simultaneous and successive synthesis. The authors do not specify, however, whether less verbal loading would necessarily reduce the serious magnitude of spuriousity. Nor is it clear that tests which are intended to measure the same traits should necessarily be independent of one another. This, in itself, would have been enough cause to argue against such measuring instrument.

Anderson (1979) suggests that the invariance of successive and simultaneous processing across IQ groups, age groups, socioeconomic classes and culture is likely to hold true because the battery of tests consists of two groups of tests which have been found to show high within-group and low-between group correlations. He claims that such a phenomenon is due to the careful selection of tests with heavy loading for simultaneous processing (Progressive Matrices, Figure Copying, Memory for Designs, Cross Modal Coding). In the case of successive processing, Anderson claims, the tests used are heavily loaded on verbal ability. On this basis, Anderson remarks:

> Given this and the notorious orthogonality of the spatial (simultaneous) and verbal (successive) factors (Vernon, 1970), it is not surprising that Das' two factors emerge in most of his investigations in which tests measuring these items are used (1979, p. 109-110).

He further argues that though the two factors are observable, it is incorrect to declare them invariant across cultures, and social classes since the tasks do not invariably load on the same factors (Ibid. p.113). It is, perhaps, evident that Anderson's argument lacks consistency. In the first place, he argues that invariance across culture is likely to be observable on the ground that Das' battery tests show high within-group and low between-group correlations. His last observation where he declares it incorrect to assume that these factors are invariant across cultures, and socio-economic classes is an antithesis of this otherwise sound criticism.

This, nevertheless, does not render the model invalid; for while a model or theory is expected to live up to its major theoretical premises, no one expects it (Mwamwenda, 1979) to be perfect. This seems to be the general trend holding true for theories such as Piaget's (1964), Eysenck's (1967), Witkins's (1974) and Kohlberg's (1968).

After all is said and done, what remains clear is that Das' model has accumulated enough empirical evidence (Das, 1973; Krywaniuk, 1974; Molloy, 1973; Jarman, 1975; Kirby, 1976; Ashman, 1978; Kaufman, 1978; Bickersteth, 1979 etc.) to merit further investigation in relation to other models and theories. Hence, the rationale for examining and determining its relationship with Piaget's theory of cognitive development.

Chapter III

PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

Piaget's theory of cognitive development is probably one of the most dominant and most researched fields in the study of children's intelligence and development (Siegel & Brainerd, 1978). Piaget (1964) traces the course of cognitive development from childhood to adulthood and identifies four principal stages, namely, sensori-motor, preoperational, concrete operation and formal operation. These stages are characterized (Furth, 1969) as follows:

1. Each stage involves a period of formation as well as a period of attainment.
2. Each structure is characterized by both the completion of a stage and the beginning of the subsequent stage.
3. The order in which stages take place is constant and does not change, whereas the age at which the stage is achieved may vary depending on the milieu, exercise, and motivation.
4. The change from one stage to another calls for integration so that the preceding structures are part of the higher stages.

This study will focus on three aspects of concrete operation, namely, conservation of liquid, transitive inference, and class inclusion.

CONSERVATION OF LIQUID

Conservation was among Piaget's (1941) earliest foundations of his theory of cognitive development (Kiminyo, 1973, Cote, 1968; Lefrancois, 1966). Conservation may be described as the child's understanding that quantitative relationships between two objects remain invariant in the face of irrelevant perceptual deformations (Brainerd, 1978).

According to Lefrancois (1966, p. 4), "Conservation refers to the realization that quantity or amount remains invariant when nothing has been added or taken away from an object or a collection of objects despite changes in form of spatial displacement". The importance of this concept has been asserted by Piaget (1941) and other psychologists. According to Piaget (1951), conservation is an essential ingredient of rational behaviour. This view is echoed by Bruner (1966, p. 183) who points out that conservation is a powerful idea for both science and every day life experiences. In no less forceful argument, Farnham-Diggory (1976, p. 380) argues that the principle of conservation in forms has to be discovered and that once discovered, its application powerfully increases mental logic. Lefrancois (1966) correctly notes that the child's grasp of the invariance of substance after deformation may not appear to be a very important developmental phenomenon as such. He elaborates that a correct conservation response is significant on the ground that it marks the end of intuitive reasoning and ushers in the period of concrete operations. Such period is the first evidence of the coordinated use of the operations of identity, reversibility and combinativity which serve as the basic foundation of mental development.

In all (Farnham-Diggory, 1976) there are seven tasks which directly fall under the umbrella of conservation: 1. The preoperational child assumes that quantity increases when liquid or sand is transferred from a shorter, wider container into a taller, thinner one (conservation of quantity: Piaget, 1952); 2. Two pencils that are of equal length are assumed to be unequal when they are not in line (conservation of length: Piaget, Inhelder and Szeminska, 1964); 3. scattered models of houses cover a larger area than when they are close together (conservation of area: Piaget, Inhelder and Szeminska, 1964); 4. it is assumed that blocks cannot be built into constructions of equal volume on bases of different areas (conservation of volume: Piaget, Inhelder and Szeminska, 1964);

5. the preoperational child also assumes that objects that are placed close together are less numerous than objects that are spread over (conservation of number: Piaget, 1951);
6. the preoperational child assumes that there is more clay when a ball of clay is rolled out into a thin sausage (conservation of substance: Piaget and Inhelder, 1941);
7. Finally, it is thought that the weight of a ball of clay is changed when it is either rolled out thin or it is cut into smaller pieces (conservation of weight: Piaget and Inhelder, 1941).

Piaget (1942b, 1950a, 1957-58) argues that a preoperational or nonconserving child has a tendency to center on one striking dimension or aspect of an object and neglects paying attention to other dimensions as a result of which his reasoning is distorted. The child, in other words, is unable to decenter, that is, take into consideration other aspects of an object that might balance or compensate the biasing and distorting effects of his tendency to center on a single dimension.

Another factor responsible for childrens' failure to conserve is what Piaget (1924b, pp. 84-88; 1950a; 1957, pp. 10-12) calls "reversibility". According to Piaget, a cognitive organization is reversible if it is capable of pursuing a series of reasonings, or follow a series of transformations in a display and then reverse direction in thought to a point of departure, that is, the original state of display or the beginning premise. Reversibility, Piaget further argues, entails flexibility and mobility of thought as well as stability of equilibrium and decentering. On the other hand, the child's preoperational thought characterized by concrete "mental experiment" is irreversible. For examp~~le,~~ in the case of liquid conservation, the child cannot visualize that once the water is poured back into beaker A, it will assume its original state; nor does he see that what is lost in width or height can be compensated. He will, instead, insist that B is wider and therefore it has more water. As the liquid is transfered into wider and wider B beakers, the child will change his mind and say that on the basis of height, A has more water (Piaget, 1952b, pp. 15-16). It does not occur to the child that A=B. Piaget points out that this may be a regulation and heuristic first step towards true concrete operation, when the child takes into consideration both the height and width of the beakers. Once this is well established, it will be clear to the child that no matter what height or width might be, the amount of water remains the same or it is invariant so long as nothing has been added or subtracted (Piaget, 1950a, p. 140). At this stage, the child is aware of the fact that the liquid being transfered from A' to B is but only one of the many possibilities of what one can do with the liquid. He is also aware that the liquid could be transfered to many other beakers: A'→B, A'→B1, A'→B2 A'→B3 without necessarily altering its quantity. The concrete child also understands that an inverse process could be set in motion: B1→A', B2→A', B3→A in which case the liquid is retransfered to the original beaker without the quantity being changed. In other words, he is able to conceptualize relations between and among objects and their different dimensions.

Piaget (1952a) claims that generally, conservation does not emerge till the age of 7-8 years of age, a claim that has been supported by numerous research investigations (e.g. Elkind, 1961; Hood, 1962; Wohlwill & Love, 1962; Gruen, 1965; Tothenberg, 1969; Kiminyo, 1973). These studies have shown that conservation operativity does not emerge until the age of 6. On the other hand, some studies have shown that children younger than six are able to conserve (Braine, 1964; Braine & Shanks, 1965; Bruner, 1966; Mehler & Bever, 1967). These studies, however, have been questioned (Modgil, 1974) on the approach they used at arriving at their conclusions.

Though Piaget holds that the acquisition of conservation skills does not materialize till the age of 7-8 years, he concedes that this may not be the case for everyone and in every society.

> In our research we say that a problem is
> solved by children of a certain age when

> three quarters of this age respond correctly. As a result, to say that a question is solved at seven years old means that already one half of the six-year-olds can solve it, and one third of the five-year-olds etc. So it is essentially relative to a statistical convention. Secondly, it is relative to the society in which one is working. We did our work in Geneva and ages that I quote are the ages we found there. I know that in certain societies for instance in Martinique, ...we have found a systematic delay of three or four years. Consequently, the age at which those problems are solved is also relative to the society in question. What is important about these stages is the order of succession (as cited in Ripples, 1964, p. 31).

On another occasion, Piaget (1961, p. 277) stated: "But progressive construction does not seem to depend on maturation, because the achievements hardly correspond to a particular age, only the order of succession is constant". The flexibility, which is not often the case with Piaget, embedded in these quotations has been borne out by many recent investigations which have indicated that the age at which conservation occurs may differ from society to society, but that what counts is the order of successive sequence which is invariant (Ripple, 1964; Borkes, 1978; Gelman, 1978; Cornell, 1978; Brainerd, 1978). On the other hand, it is interesting to note that some researchers (e.g. Siegel and Brainerd, 1978) have made a big issue out of this flexibility. They have used the evidence that some children conserve at an earlier age than Piaget observed as a refutation against Piaget's claim. This, to say the least, is a misrepresentation of Piaget.

Developmentally, Piaget (1964) argues that there are three invariant stages in the acquisition of conservation. During the first stage, children are totally unable to conserve; when they observe that transformation has occurred to one of the given objects, they automatically assume that the quantitative relationship has also changed. For example, they would argue that glass B has more water than glass A. During the second phase, children give responses which Piaget calls "intermediate reactions" by which he means that some-times children conserve and other times they do not conserve. This may be interpreted as a state of disequilibrium. During this stage, there are two types of responses: when the deformation is relatively small, they are likely to give conserving responses, whereas when it is large, they will give nonconserving answers. The second type of intermediate response is concerned with conservation prediction. This means that when the child is asked to predict the relationship between the two objects before deformation, he is likely to give a conserving response. No sooner is the deformation performed than the child reverts to a nonconserving response.

In view of this, Piaget holds that the transition from preoperational to concrete operational thought is relatively short and unstable. In other words, the cognitive structure of the two stages coexist. This is used as a possible rationale for a stage II child giving either preoperational or concrete responses (conservation-nonconservation).

On the other hand, during the third stage, the child is not only able to conserve, but he is also able to predict. Even in the face of deformation, he still maintains conservation response. Brainerd (1978) points out that the three stages of conservation correspond to three stages of cognitive development, namely, sensory, preoperational and concrete operations.

The question is why are some children able to conserve and yet others are not: what do stages II and III children possess that stage I children do not? One simple answer is that they have operations. The problem, however, is that operations and cognitive structures cannot be measured; they can only be inferred from behaviour of conservation. According to Piaget (1941), stage II and III children understand the principle of reversibility.

Piaget (1977) identifies two reversibility rules: inversion (negation) and compensation (reciprocity). Piaget argues that by definition, concrete operational children have a mastery over these rules and that their reasoning is influenced by them. This is not the case with stage I children.

Piaget (1964) concludes, therefore, that before children can conserve, they have to understand the principle of reversibility.

While Piaget capitalizes on reversibility, compensation and inversion as prerequisites for the emergence of conservation, Bruner (1966) and Elkind (1967) have stressed on qualitative identity and quantitative identity, respectively, as prerequisites or preconditions. By qualitative identity, Bruner (1966) refers to children's grasp that despite the deformation, the object has not changed; it is still the same. By quantitative identity, Elkind (1967a) refers to children's grasp that despite the deformation, the amount is still the same. Examples of these might be useful. The experimenter may ask the child "Is there the same water in this glass as there was before in this glass?" If the answer is positive, it is a quantitative type. A qualitative identity type would be as follows: "Is the water ~~in~~ this glass the same water that was in glass Y?" If the answer is positive it is quality identity. The positions advocated by these theorists are known as test rules of conservation (Brainerd, 1978; Lefrancois, 1966). It's contended that children must pass rule tests and conservation tests invariantly. For example, if children are tested on conservation and perform well, it would be rather unlikely for them to fail rule tests. It could further be argued that if there was a group of children who could not conserve and then they were taught the rules (compensation, inversion, qualitative and quantitative identity) their performance would change for better. In a training situation, it may be reasonably assumed, it would be easier to train children who understand the rule tests than those who do not.

Interestingly, the relationship between qualitative identity and conservation has been examined by many researchers (e.g. Bruner, 1966; Hamel, 1971; Van der Veer and Westerhof, 1972; Lefrancois, 1966) and the general consensus is that most children understand the four rules before they conserve. Bruner et al (1966) and Hamel (1971) observed that their subjects understood the variable stimulus to be the same object as before deformation earlier than they could conserve.

The developmental relationship between quantitative identity has also been examined by more than a dozen research studies (Brainerd and Hooper, 1975). They generally concede that children understand that the variable stimulus is still the "same amount" prior to their understanding conservation. It has also been observed that the lag between qualitative identity and conservation is shorter than is the case between quantitative identity and conservation.

In addition to qualitative and quantitative identity as prerequisite skills to conservation, researchers introduced two other skills namely, inversion and compensation. Larsen & Flavell (1970); Gelman and Weinberg (1972); Curcio, Kattef, Levine and Robbins (1977); Blanchard (1975) and Brainerd (1976b, 1977a) have explored the developmental relationship between compensation and conservation. The first two research studies found no consistent relationship. However, their findings have been counterbalanced by the later studies which have consistently indicated that children grasp compensation long before they are able to conserve.

Murray and Johnson (1969), Blanchard (1975), and Brainerd (1977a) have reported a developmental relation between inversion and conservation. Children understand that inversion of deformation is likely to bring about the original state of an object before they can conserve. The lag between inversion and compensation is about 2 years. In passing, it may be noted that the acquisition of the four rules may involve invariant sequence (Brainerd, 1974). The order is as follows: inversion → compensation and qualitative identity → quantitative identity.

These four underlying processes have been used in facilitating the development of conservation in nonconservers. For example, Hamel (1971), Hamel and Riksen (1973), and Siegler (1972) have examined the effect of qualitative and quantitative identity and their conclusion was that the nonconserver's performance improves considerably following identity rule training. Similarly, the effects of compensation training have proved to be facilitative in acquiring conservation concepts (Goldschmid, 1968; Ralford and Fullerton, 1971). In both studies, it was observed that subjects who had failed conservation improved their performance following training in compensation. The same holds true in inversion training which has proved to have a great impact on conservation (Beilin, 1971b, Brainerd, 1973b; Brainerd & Allen, 1971a; and Glaser & Resnick, 1971). In fact, inversion appears to be the most effective of the four rules.

In place of arguing from Piaget's point of view or Bruner's as to why preoperational children fail conservation tasks, this study proposed that Das' model of information processing may be a parsimonious dimension from which Piaget's conservation tasks could be examined. The nature of conservation is such that a person who processes information simultaneously should be able to perform better than a successive processor. The description of preoperational children's manner of responding to conservation problems seems to match what Das (1973) calls successive synthesis.

In summary, Piaget contends that a nonconserving child has a tendency to center on one striking dimension of an object. This leads to his failure to account for other relevant variables of an object. Being able to coordinate the various aspects of an object and being able to see relationship among them is a prerequisite for conservation. Such a prerequisite is embedded in the nature of simultaneous synthesis. Similarly, reversibility is a two-way process in the sense that it requires the subject to pursue a series of transformations in a display and then reverse direction in thought to the original state. Nonconservers tend to use reversibility as a one-way process which means that they process information successively. Consequently, they are unable to realize that the original state of water remains invariant. With the aid of a simultaneous synthesis, the child is able to conceptualize relationships between and among objects and their different dimensions. In this context, simultaneous synthesis is a more appropriate strategy for performing well on conservation of liquid.

TRANSITIVE INFERENCE

Transitive inference is another Piagetian concrete operational task that distinguishes preoperational from operational subjects. Transitive inference may be defined as a type of reasoning in which a relationship between a first (A) and third (C) terms can be inferred given that a relationship exists between the first (A) and second (B) and between the second (B) and the third (C) terms (Brainerd, 1978; Thayer and Collyer, 1978). For example, if A is longer than B and B is longer than C, it is a conceptual truth that A is longer than C.

In a transitive inference task, the child may be given three balls which look identical, but have different weights (e.g. A=50 grams, B=100 grams and C=150 grams). First, the child is asked to compare A to B and decide which is heavier; secondly, he is asked to compare C to B to determine which is heavier. He ~~is~~ not, however, allowed to compare C to A. After the child has compared both A and C to B, he is asked to infer or deduce the relationship (in terms of weight) between A and C (Piaget, Inhelder and Szeminskia, 1960). The child who reasons that C must be heavier than A because B is heavier than A, but lighter than C is said to possess the concept of transitive inference.

Piaget's (1941) basic concern in transitive inference is whether children can seriate a given number of items and be able to make inferences resulting in new information. In Bruner's descriptive phrase, it is a question of going beyond the given information. Piaget argues that unless a child has reached the concrete operational stage, he is incapable of performing a transitive inference task. In comparing weights of three objects, the preoperational child is likely to do two things: a. he will compose a complete series either correctly or incorrectly by only establishing that $A<B$ and $A<C$ given the arrangement $A<B<C$. The child is not sure that $A<C$ can be derived from the fact that $A<B$ and $B<C$. His failure to do so is due to (Falvell, 1963) his inability to visualize that in an asymmetrical series, each object must be simultaneously understood in the light of both a direct and an inverse relational operation. In other words, object B must be both larger than A and smaller than C to assume a middle position $A<B<C$. Piaget (1941) suggests that such failure may be a function of: a. the child's assumption that $B<C$ on the basis that $A<C$ and $A<B$; b. his reluctance to conclude that $A<C$ from $A<B$ and $B<C$; or c. a lack of the required cognitive ability to deal with asymmetrical series adequately. Piaget (1960; Flavell, 1963) further suggests that a child's failure in transitive inference tasks may be due to the fact that he is dominated by immediate perceptual input and fails to recognize the input once he is faced with additional perceptual items. Secondly, the child does not understand reversibility that one object can have more than one relationship or possibility. Similarly, Beilin (1975) argues that the child's cognitive operation is limited and that he lacks reversibility. Consequently, it is not easy for him to impose structure where it does not exist. Flavell (1977) and Smedslund (1963) have suggested that the child's failure may be due to: a. the child's failure to understand the instruction given by the experimenter; b. the child's failure to understand that A is longer than B and that B is longer than C; c. the child's failure to remember the two premises ($A<B$ and $B<C$) long enough to make the transitive inference.

According to Piaget (1960), if a child fails to perform well in transitive inference tasks, it is indicative of his inability to logically add the relation $A<B$ and $B<C$ to infer that $A<C$. Piaget's claim about transitive inference as well as the age at which it emerges has been confirmed by other researchers (McManis, 1969; Murray and Youniss, 1970; Youniss, 1975; Youniss & Murray, 1968; Smedslund, 1960, 1963; Youniss,

and Furth, 1973). In testing transitive inference, Youniss (1975) presented the subject with two rods, B and D, which had a length difference of 1/8 of an inch and then the subject was asked to determine which of the two rods was longer or taller. Following this, he was shown other rods in comparison with B. and D. In this manner, the subject was provided with premises on which to base his inference. For example, in Youniss's (1975) study, rod A was located beside B so that the subject could grasp and perceive that $A > B$. Then the subject was shown $D > E$ followed by the middle term C which was placed next to B and rotated 90 degrees next to D. The child had a complete view of $B > C$ and $C > D$. He was then asked which of the two rods on the board was taller, B or D? In this experiment, three approaches were employed: 1. $A > B > C > D > E$; 2. $A = B > C = D > E$, and e. $A > B = C > D = E$. According to Youniss (1975), in all the given three situations, B is longer than D in view of its relation with C. The results were that most subjects whose age ranged from 7½ to 9 and 12 performed well on transitive inference. Similar results were obtained in other studies (Murray & Youniss, 1968; Youniss & Dennison, 1971; Youniss and Murray, 1971). Summarizing all these studies, Youniss (1975) writes:

> The common age span for these experiments was 7 years and 6 months to 9 years and 2 months. In the three respective experiments, the numbers of subjects who passed the criteria of success in this age span were 25 of 48; 17 of 32 and 16 of 32. It appears that about 50% of the 112 children seen within this span were capable of manifesting transitivity in an operational sense. (p. 239)

In passing, Youniss also notes:

> If logic is neither innately given nor induced from an objective environment, it must come from a third source. Piaget has identified the child himself as the constructing agent who builds logic into his mental action systems by reflecting on each prior step in operational development (Youniss, 1975, p. 244).

Piaget's (1960, 1971, 1941) claims about transitive inference have been challenged (Brainerd, 1978) by a number of researchers. Braine (1959, 1962), for example, argues that Piaget's measure of transitive inference is faulty in that it asks for more than transitive inference, thus making it more difficult than it should be. It has also been pointed out that (Brainerd, 1978; Bryant, 1973) Piaget's tests require a) the ability to resist visual illusions; b) language ability; c) and memory ability. All of these, it is assumed and contended, have very little to do with transitive inference. Piaget is charged with incorporating visual illusions into transitivity tests. For example, in length conservation, the child is asked to compare three sticks: A, B, C; following this, Piaget attaches outward-pointing arrow heads to the shorter stick, C. and attaches inward-pointing arrow heads to the longer stick, A. He thus involves what is called the Muller-Lyer illusion. Such procedure, it is argued, gives the impression that A is shorter than C when in actuality, the opposite is the case. In the weight transitivity test, the lighter of two outside balls (C) are made to appear twice as large as the heavier of the two balls (A). (This is called size-weight illusion). It is argued, therefore, that in both instances children may fail transitive inference because they are unable to resist the visual vision rather than because they do not have the required competence. As regards factor (b), Piaget requires that transitivity inference be verbally explained logically against which Brainerd (1975) argues that children who are not linguistically equipped are likely to perform poorly. What fails them, he argues, is their language ability rather than their competence. In factor (c), it is vital for the subjects to remember that A<B, and B<C, if they are to deduce that A<C. Once they forget this basic rule, there is no way, perhaps, they will make the appropriate transitive inference (Brainerd, 1978).

An elimination or control of the described factors leads to, so it is argued, a drastic change in transitive inference performance; children are able to do transitive tasks at an earlier age than Piaget's findings have shown. If one factor is eliminated, five-year olds are generally (Brainerd, 1978; Gelman, 1978) able to perform satisfactorily in transitive inference tasks. Factors (a and b) were controlled by not incorporating visual illusion and by not asking children to give logical explanation to their answers in studies carried out by Brainerd (1973a, 1974a), Brainerd and Vandeu & Heuvel (1974). Consequently, the majority of kindergarten subjects performed well in the given tests. Roodin and Gruen (1970) controlled or eliminated factors (c & b) by not asking children to give logical explanations and by giving them memory hints. In carrying out the latter, Roodin and Gruen reminded the subjects the relationship between A and B and B and C prior to their performance. This led to 75% of the kindergartens passing the test. Further testing showed that without controlling the memory factor, only 25% passed the transitive inference task. Other research studies (e.g. Siegel, 1971a, 1971b; Bryant, 1974) have made similar conclusions. Bryant et al (1971, 1973, 1974) argue that Piaget failed to control the memory factor in his experiments and that children's differences in performance may be due to memory processes involved rather than a lack of logical competence. It is argued that (Thayer and Collyer, 1978) before one concludes whether inference is achieved or not, it must be ensured that the subject recalls the comparisons that have to be combined ($A<B$ and $B<C$). This is precisely what Bryant implemented in his experiments. The comparison and colours: $A>B$, $B>C$, $C>D$, $D>E$. They predicted that making a correct inference on the B D test was the probability of being able to bring to memory the information for each of the initial training pairs $B>C$ and $C>D$. This hypothesis was confirmed.

Counter criticisms have been made against the reported criticisms of Piaget's assertions and claims. The counter criticisms, if anything, vindicate Piaget. As regards Piaget's failure to control memory factors, Flavell & Wohlwill (1969) and Smedslund, (1963) defend Piaget's failure or neglect by arguing that training subjects to recall the various sets would not be tantamount to what Piaget calls true operation. It would, they argue, only produce it to a semblance of true operation. The effect of such training would be of short duration and would be less susceptible to transfer, but would be highly situation-or-task-specific. Flavell et al (1969) also argue that the procedures employed in training are too narrowly confined to psychological processes instead of the more important cognitive structures. While this may be true, it would appear that the psychological processes involved in encoding decoding may be of greater value in understanding how people arrive at certain information than the traditional content-oriented approach.

In reference to the influence of illusion in transitive inference, Smedslund (1963) contends that it is essential to have it as it differentiates between those who respond on the basis of perceptual cues and those who in fact have transitive inference operation. The latter will always choose C as longer despite the illusion. Piagetians justifiably argue (Thayer and Collyer, 1978) that:

> ...if a subject cannot overcome the perceptual domination, then transitivity is not sufficiently developed to be labelled an organized structure (p. 1331).

Youniss & Furth (1973) have criticized Bryant and Trabasso (1970) for failing to vary the comparison in all possible ways; for example, instead of only using the $A>B$, $B>C$, $C>D$, $D>E$ comparisons, it is suggested that they could have included the following combinations: $A>B>C=D>E$ in which the relation of equality between two sets of terms is less obvious. It is also argued that for researchers to ascertain that transitive inference is attained, the subject should be able to generalize to unfamiliar but related situations (Flavell, 1977; Smedslund, 1969). According to Youniss & Furth (1973), both Bryant and Trabasso failed to show this as a result of their using restricted comparison relations. Their argument has been empirically supported. For example, in one of their experiments, they varied the length of the three sticks; the nature of the task involved the following: $A>B>C$, $A>B=C$, and $A=B>C$. The results showed very few children who were less than 6 years had acquired the concept of transitive inference; among those who were 7 years and six months to 8 years, only 50% performed well. It was noted also that when $A>B>C$ was used there was no clear-cut difference in performance on the basis of age. Age difference was distinct when $A=B>C$ condition was employed. In view of this, it is suggested "perhaps the $A>B>C$ relation is not sufficiently sensitive to noninferential judgments" (Murray et al., 1968, p. 1267).

Transitive inference may be identified as either passive or active (Thayer & Collyer, 1978). By passive is meant that the subject is told that $A>B$, $B>C$, etc. Tasks used by Bryant and Trabasso (1975), Riley and Trabasso (1974), Trabasso, Riley & Wilson (1975) were of this kind. Such approach is different from Piaget's discovery approach where the subject is expected to find out the premises for himself. Interestingly enough, Bryant and Kopytynska's (1976) investigation showed that when an active approach was employed, the findings were in concordance with Piaget's claim. In another study (Bryant, 1973), it was observed that "All children had previously done very well in a passive inference task, yet they were plainly at a loss in our active".

To date the argument on how transitive inference should be assessed has not been settled. On this argument, there are two schools of thought, if not more. One advocates that the child's judgment should be sufficient to determine whether he has the concept of transitive inference (Braine, 1959; Bryant, 1973, 1974; Bryant & Kopytynska, 1976; Bryant & Trabasso 1971; Trabasso, 1975; Youniss & Murray, 1970). The second school advocates that in addition to the child's judgement, there must be an explanation or justification for his choice (McManis, 1969; Smedslund, 1960, 1963). Smedslund (1963), Flavell and Wohlwill (1969) strongly argue that verbal explanations are an essential ingredient for verifying whether or not the child has a genuine cognitive structure. They further point out that unless such a criterion is employed, researchers will have difficulty determining whether the subject used a transitive or nontransitive solution. In reference to this, Thayer (1978) correctly points out:

> Investigators who require a satisfactory explanation in addition to the judgement, clearly apply a more stringent criterion; it might be expected that this diagnostic conservation would elevate estimates of the age of emergence of transitivity (p. 1334).

The age does not have to be elevated except that it will remain in agreement with Piaget's claims. Flavell's (1971, 1977) rationale for discrepancies between Piaget's claims and other researchers' findings on when transitive inference is operational is worth taking note of. He identifies two major components involved and calls them "evocability" and "utilizability"; the former refers to the child's initial acquisition of transitive inference. During this period, the child finds it difficult to evoke such ability and use it in a variety of situations; the latter refers to the child's fully operational transitive inference. Thayer and Collyer (1978) concisely and logically describe the two components as follows:

> The research from the Piagetian group, which has identified age 8 as the age of emergence of the operation of transitivity, may actually have identified the age at which the principle can be actively and spontaneously applied in most situations. At this age, the child's levels of evocation and utilization are strong and consistent. On the other hand, Piagetian methods of diagnosis exclude those younger children for whom transitivity is evocable, given appropriate environmental conditions, but not yet spontaneously utilized in the absence of special conditions. It is reasonable to assume that newly developing cognitive skills need some environmental or practical support in order to exhibit the levels of evocability and utilization we see in the 8-year-olds. Transitive inference may become available to the young child by age 4 or 5 under optimal conditions of training, feedback, and so forth; however, there is some reason to judge that the principle is not fully developed until age 8 or 9, when it can function reliably with minimal environmental support and across many varied situations (p. 1337-1338).

This description is inalienably embedded and reflected in

Piaget's description of the emergence of various concepts including that of transitive inference. He remarks:

> In our research we say that a problem is solved by children of a certain age when three-quarters of the children of the age respond correctly. As a result, to say that a question is solved at seven years old means that already one-half of the six-year-olds can solve it, and a third of the five-year-olds etc. (cited in Ripple, 1964, p. 31).

Flavell (1963) notes that the subject's failure in transitive inference may be due to his inability to visualize that in an asymmetrical series, each object must be understood simultaneously in the light of both a direct and an inverse relational operation. Similarly, Piaget argues that the child's failure may be a function of his failure to understand reversibility that an object has more than one relationship.

Therefore, what is basic to transitive inference is one's ability to go beyond the information given. To do this requires more than recalling a series of events; it calls for one's ability to abstract some new information from what he has at his disposal. Consequently, a successive mode of information processing would probably be inadequate to enable a subject to go beyond the information given. In Jensen's (1969) Level II description, it calls for the subject's ability to transform and manipulate the stimulus before arriving at a response. Hence, the rationale for assuming that simultaneous synthesis would be more facilitative in transitive inference than successive synthesis.

CLASS INCLUSION

Classification may be defined as a process by which objects which belong together are placed together on the ground that they have the same properties in common (Piaget, 1964, 1952, 1958; Inhelder and Piaget, 1964; Gruber and Voneche, 1977). Arguing for the universal existence of classification, Kariuki (1979, p. 2) states:

> Classifying is a universal phenomenon- a way of life. Children in African environments do most things from observation and imitation of their elders. In the Kikuyu environment, little boys play with sticks, small wooden spears and shields, bows and arrows. These vary in size and the biggest goes to the biggest or oldest boy while the smallest goes to the smallest or youngest boy.

Sufficient empirical evidence has lent support to this argument (Bickersteth, 1979; Fobih, 1979). In a similar vein, Bruner (1964) states that everyone in one way or another is engaged in some form of categorization and classification. Brainerd (1978) logically notes that the importance of classes cannot be overemphasized. He further notes that classes are used for grouping objects and that without classes, every object would have to be dealt with individually. Thus, classes reduce our world to a relatively manageable size.

Class inclusion, as part of classification, calls for the child's understanding that a class must always be smaller than any more inclusive class which contains it (Brainerd, 1978). Or as Kariuki (1979, p. 9) puts it: "It is the understanding that a total class must be as big as, or bigger than one of, its subclasses". In practical life, this may be illustrated by the fact that there are fewer robins than there are birds; there are fewer men than there are people, there are fewer tulips than there are flowers; there are fewer verbs than there are words (Brainerd, 1978). In each of the given illustrations, the second class contains all members of the first class and more. The second class is known as superordinate class, the first one called "subordinate classes". According to Piaget (1951), a mastery of class inclusion is one of the important aspects of concrete operation. Piaget observes that the concrete operation stage is marked by defined properties such as reversibility, associativity which Piaget examines in terms of logical-mathematical structures. He believes that logico-mathematical structures are a model of organization and process of cognition in middle and late childhood (Piaget, 1949a, p. v; 1950a, p. 29). They form what he calls an ideal pattern which the living operational systems in the subject approximate.

When Piaget says that a child at this stage has a classificatory behaviour which shows that he is in possession of the "grouping of logical class addition", he means that the child's thought of organization in the classificatory area has formal properties such as reversibility, associativity, composition tautology that are akin or similar to those used for defining logical-algebraic structure. Obviously, the latter has certain specific definable system properties, whereas in the case of the concrete operational child, it is inferred from his behaviour (Flavell, 1963).

The concrete operational child is not only able to form classes in a hierarchy, but also is capable of decomposing classes from a supraordinate level to a subordinate class e.g. $A+A' \Rightarrow B$, $B+B'=C$. In a reverse order, it would be: $B-A=A'$, $B-A'=A$ etc.; such operation indicates the reversibility and mobility of thought in the child's cognitive structure. The child is able to compose a new class on the same old given data; he has acquired a grasp of the relation between subclasses and their superordinate class. The ability to operate on class inclusion is referred to as "reversible equilibrium" (Piaget, 1952) in which subclasses are seen from two point of views: one as classes in their own right, and secondly, they are viewed as members of the same class as shown in this equation: $A+A \rightleftarrows B$. This would indicate that the concrete operational child is capable of thinking of the parts as discrete from the whole and the whole simultaneously. In examining A and A', he bears in mind the relationship they share or hold with the superordinate class B.

Such achievement is appreciated even more when it is understood that given a task which involves class inclusion, a preoperational child is not able to give it a logical analysis, as it will be seen in a detail analysis of some of

Piaget's (1959) experiments in class inclusion.

In the classification of flowers mixed with other objects the experimenter used 20 pictures, 16 of which represented flowers and four of them represented coloured objects. Eight of the flowers were primulas, four of which were yellow and the rest were of different colours. The arrangement was as follows: A (yellow primulas) < B (primulas) < C (flowers) < D (flowers and other objects). In addition, the experimenter used beads; these were made up of these classes: A (red square ones) < B (red beads, round and square) < C (wooden beads with different colours) < D (wooden beads and glass ones). These problems were grouped as follows: 1. spontaneous classification; 11. general questions on inclusion: "suppose you make a bouquet out of all the primulas, are you going to use (blue) primulas"? 111. four types of questions on quantification of inclusion: 111A "Is the bunch made of ...(e.g. the yellow primulas), bigger or smaller or the same as the bunch of all...(e.g. the primulas)?" 111B. "Are there more...(primulas) or ... (flowers)?" 111C. "Suppose all the primulas are removed will there be any flowers left"? 111D "Suppose all the flowers were removed, would there be any primulas left"? All these problems were presented to stages: 1, 11 and 111 children.

In problem 1, Piaget (1959) observed a continuous trend towards logical arrangements. Most young children could at least manage four parallel collection although their criteria kept on changing. Older subjects indicated a spontaneous, but more differentiated criteria or logical arrangement: A=the primulas; A'=the other flowers; B (=A+A')= all the flowers; B'=the other objects; and C(=B+B') all the objects. Piaget admits that it is difficult, nevertheless, to determine whether responses constituted true "groupings" involving both reversibility and class inclusion (A=B-A') or it is just nongraphic collections since there is no class inclusion. The answer to this is revealed in type 11 problems where it is clear that the given answers do not measure up to what is required of classification. For example, in the first problem, the children think everything is part of everything else or vice versa. In the type 11 problems, the subjects put A and A' together to form B, though they are unable to understand it. Granted that all the As are Bs, not all the Bs are As. In the last phase or stage, there is a definite indication that children grasp the relations of class inclusion. The subject, for example may argue that a primula is also a flower, indicating that he has constructed the relation $A<B$. This is further confirmed by his response to the next question: "Is an A' one of the As"?

On the other hand, the type 111 problems show that the described subjects cannot handle quantitative comparison of A (part) and B (whole). To do this successfully, they have to separate B into A and A' without losing its identity. Stated differently, the relation $A<B$ implies the inverse relation $A=B-A'$, thus enabling B to exist despite its components being separated in thought. Piaget (1958) observes that no sooner are A and A' separated than B is lost sight of by the subjects. Hence, they are stuck with making a comparison between A and A'. Some subjects argue that there are more primulas (A) than flowers (meaning A' the other flowers). Some will argue that there are more A' than A, whereas others will say they are the same. Piaget notes that this type of response is typical of most stage 11 children. He also observes that since the type 11 problems precede type 111 problems, they should make the latter a little easier. Furthermore, the experiment used was different from that of the beads. In this one A and A' were equal in number (the previous experiment had the ratio of 10 to 1 or 2 compared to the current one which had four yellow primulas and four other colours). Piaget rhetorically asks why subjects should perform well on type 11 problems and yet fail on type 111 ones. He rejects the suggestion that it was because they did not grasp the language used;

> We cannot accept the answer that they did not understand the language we used. In every single case we took good care that they did. (Piaget, 1959, p. 377).

Piaget also observed (1959) that when a state II child responds correctly to type II problems his thinking is qualitative (the yellow primulas belong to the primulas because they are primulas). The subjects use spatial extension as the only extension available to them. "All" is used as an intensive quality belonging to the whole as a unity. The child, Piaget points out, finds it very difficult to deal with extension and as a result his ability to solve type II problems is limited. Type III problems demand that the child use more than extensive structure to solve them, What is rather paradoxical is that between 50-90% of 5-7 year olds who are unable to perform well on IIIA and B problems, perform well on IIIC and D. For example, the same subject responds that there are more primulas than flowers in a given bunch; he will simultaneously say there will be some flowers left after picking all the primulas and that if all the flowers were picked there would be no primulas any more. Piaget suggests that most of their answers are correct, except that the same subjects will not accept that a collection (all flowers) is of greater size than a subcollection (all the primulas). This is not in agreement with Piaget's conclusion that subjects of this age are incapable of making a comparison between a subcollection A with the collection B without eliminating B so that they end up with comparing A and A'. Piaget speculates that it may be argued that all the wrong responses to questions IIIA and B and the errors made in the use of "all" and "some" are a manifestation of verbal misunderstanding. He further points out that when the children are presented with concrete and familiar questions, they have no problem dealing with class inclusion; they also show that they grasp the subtraction B-A=A' (the flowers minus the primulas=the other flowers).

Furthermore, Piaget (1964) asserts that the statement (1) that after taking away all the primulas (B), there won't be any yellow primulas (A) left and (2) the statement that if yellow primulas (A) are taken away, the purple ones will remain (A') express the operation: A+A'=B and B-A=A' applied to classes A, A' and B. To ascertain that such operation exists in the child or the child is in possession of it, Piaget suggests, it is important that B be retained in the mind of the child. The retention of B would indicate that logical subtraction is the inverse of addition. From (1), it is understood that B (the primulas) consists of two parts: A (yellow), and A' (mauve); it follows that once the whole is taken, the two parts are taken. From (2), it is clear that A' remains when A is taken away. This, Piaget adds, does not imply that B still retains its identity after the separation. The union A+A'=B still holds despite (a) mobility of parts; (b) reversibility of the transformations (+ and -) or (c) preservation of the whole (B). All these have to be present in the subject's mind to be considered operational addition, or else they are just intuitive apperception (Piaget, 1959). To test the presence of this, the subject is asked to make a comparative analysis of the extension of B with that of A. Should the subject be cognizant or conscious of there being more primulas than yellow primulas, it would indicate that he knows that B is the sum of A+A' and that, simultaneously, he is aware of the fact that A is the difference of B-A'. This is typical of operational thinking and implies that the subject is capable of conserving the whole (B). Though stage 1 subjects are aware, intuitively, that the whole is the sum of its parts (statement 1) and that these parts are from each other, they are unable to compare the extension of the part and the whole. Such comparison is not suggested by statements 1 and 2. Inasmuch as the subject is able to compare A and A' (B being temporarily out of existence) is indicative of the fact that statement 2 is devoid of or does not express the logical subtraction; it only expresses simple intuitive separation of A and A'.

Piaget (1959) observed among his subjects that failing to solve class inclusion, the subjects resorted to comparing A and A' instead of A and B. Their reducing B to A may be a function of their reasoning or assumption that the same elements (Wilkinson, 1976) cannot be used in two different ways.

Piaget (1964) also notes that 8-year-old subjects differ from 5 - 7-year olds in that they classify correctly and are able to recognize the inclusion suggested by: (A+A'=B; B+B'=C; C+C=D). They experience no special problems in solving type 11 problems. Moreover, they are able to compare the extension of the part and of the whole. In other words, the whole retains its identity notwithstanding its being conceptually divided into more than one part. Typical answers are clear "The one who takes all the flowers (will have more) because he takes the primulas as well". The statement is characterized by coordination between extension and intension.

Another experiment in classification involved animals and the type of problems presented were similar to those noted in the experiment or flowers and beads. It is important to note, however, that children's performance in animal classification far lags behind that of flower classification (Piaget, 1959). The rationale for this difference is that in the experience of the child, the animals are less familiar than flowers, and as such they are remote and demand that the child be able to engage in abstract thinking. Piaget admits that circles and squares, primulas and flowers are designated by words embedded with verbal concepts of generality, thus placing them in the category of abstract. Despite this, it is also evident that from the age of five or earlier, children pick flowers when they go for a walk or if they happen to live in a countryside. Had actual birds and ducks been used, probably the children would have had no problem performing class inclusion. Since in the classification of animals, the child lacks concrete experience, he is forced to depend on linguistic concepts. This, Piaget concludes, may account for his lag in animal classification. In other words, for children to perform well in Piagetian tasks, prior concrete experience with the material is imperative.

Different rationales have been advanced to account for the child's poor performance in classification or class inclusion tasks (Gelman, 1978). It is suggested that if children are given material that they can organize in their own way and on the basis of their understanding, it would lead to better performance. For example, Odom, Astor & Cunningham (1975) have shown that 4 - 6-year-olds perform well in matrix classification if they are given two of the three dimensions that are most salient to the subjects than would be the case if they were dealing with a two-dimension object where only one is salient. It is also argued that some exemplars are more facilitative than others (Carson & Abrahmson, 1976). For example horses and dogs would make a good example of the animal category, whereas flies and bees would not. In testing children in class inclusion, they are asked "Are there more horses or animals?" Their performance tends to be better than when dogs are put together with bees or horses and flies (Ibid.).

Westman & Youssef (1976) advance the argument that kindergarteners' failure to see commonality of category may be partly due to their being given too many exemplars of a specific category. It is implied that kindergarten children should be able to learn many categories which have a few members instead of a few categories which have many members. Such claim received support from a study of second and fifth graders conducted by Worden (1976). It was shown that second graders did as well as fifth graders and that the only difference observed was the number of items included in each category.

Gelman (1978) contends that the child's classification is not only affected by the nature of the stimuli characteristics, but also the way the experiment is designed and administered could have a great impact on the subject's performance. For example, Worden (1976) attributes the good performance in organizing their material to the fact that they were left free to their own organizing. Odom et al (1975) indicate that as a result of allowing subjects more than two trials, less errors were made in classification. Hence, he concludes: "This strongly suggests that repeated presentations may be required to obtain a valid assessment of a young child's cognitive ability to classify multiplicatively" (p. 276). Odom's conclusion bears much weight (Gelman, 1978) since most of the early studies of classification were done on a single trial or two the most.

Research studies by Ahr and Youniss (1970) indicated that, poor performance in class inclusion was partly due to the pre-operationals' attempt to compare subclasses to the exclusion of accounting for one subclass in relation to the supraordinate class.

Another cause for poor performance could be a function of the subject's strategy which may be in conflict with what the experimenter expects of him (Wilkinson, 1976). It is suggested that may be the child arranges the different objects by means of counting so that his grouping would be based on what he has counted and what he has yet to count. The problem with such a strategy is that once the counting has occurred, the chances of re-examining the material is almost out of the question. The nature of class inclusion (Gelman, 1978; Wilkinson, 1976) tasks seems to foster such strategy. For example, "Which is more the flowers or roses?"; if the roses have been counted, the child may see no need of recounting them since this would be a violation of the principle of enumeration which, speculatively, says an object can be counted only once (Gelman, 1978). In terms of Das' model, the subjects are using a successive mode of information processing for a task that calls for simultaneous synthesis (Krywaniuk & Das, 1976).

Gelman further contends that most children fail Piagetian tests because they are unable to follow the experimenter's rules. Their failure, he confidently asserts, as such may have nothing to do with their cognitive ability. It is suggested that the subjects' ability to perform on a Piagetian task should not be based on a single test; there should b a variety of testing before the examiner can confidently assert the results as valid (Gelman, 1978). Such suggestion has been implied in other tests relating to Witkin's (1974) theory of psychological differentiation (Vernon, 1972). The suggestion was made in the context that there is no single test that can truly measure what it claims, without measuring other aspects of cognitive ability. In this view, it should be supplemented by other similar tests.

Markman (1973) also argues that among 6-to-8-year olds, correct responses to class inclusion tasks is influenced by the questions posed. For example, in comparing superordinate classes by using the word family as a substitute for superordinate class and parents and children as substitute for subordinate classes, she observed that it was more facilitating and enhancing in terms of performance than the traditional approach. Siegel, Macahe, Brand and Matthew (1977) have demonstrated that 3 and 4-year-old subjects can perform well in class inclusion if they are given a variety of candy consisting of smarties and jelly beans. There were more smarties and the subjects were asked whether they would prefer eating the smarties or candies. They chose to eat both. The same children did not perform well on Piagetian traditional questions (e.g. "Are there more smarties or more candies?"). Similarly, it has been suggested by other researchers (e.g. Brainerd, 1978) that failure in class inclusion is partly due to the subject's responding to the relative size of the subordinate classes (A & A') instead of responding to the relative size of the superordinate class as well as the larger subordinate class (A). This train of thought is shared by other researchers (e.g. Ahr & Youniss, 1970).

Wohlwill (1968) believes he has an explanation for children's poor performance; his explanation is in the form of two hypotheses, namely, perceptual set hypothesis and misinterpretation hypothesis. The former's main focus is on the stimulus material and the latter focusses on the type of questions raised. First of all, it must be recalled that when Piaget (1964, 1958) was testing subjects in class inclusion, he showed them forty brown beans (A) and two white beads (A'). On the basis of the performance explanation, such task involves a lot of discrepancy which leads to the development of "a perceptual set". This perceptual set makes children focus on the A/A' relation (since it is salient) instead of A/B relation. The misinterpretation hypothesis postulates that the questions used for eliciting responses are tricky. For example, it is argued that questions such as "Are there more As or Bs?" are deceptive to the extent of hampering accurate interpretation. In responding, children assume that they are asked "Are there more As or more A's". Basically, this explains why subjects perform poorly in class inclusion.

Piaget (1959, 1964) has advanced his own rationale why subjects perform poorly on classification in general and class inclusion in particular. It is imperative, Piaget stresses, that the child grasp class inclusion, that is, the way members of a subclass belong to a class. The key to this understanding requires that the child should be able to comprehend the relation between "some" and "all". He must, for example, know: 1. that all daisies are flowers and that 2. only some flowers are daisies. Piaget contends that before the age of 10 years, children find it increasingly difficult to handle this asymmetry in the relation between the including class and the class included. Subjects have an inclination or tendency to perceive symmetry in the relation between class and subclass. For example, if a child is told that all the Jews were gassed in Germany, he will conclude that there is no person left since all of them are dead (Farnham-Diggory, 1976). Piaget points out that such relation can only be grasped with the aid of reciprocal adjustment between intension (the predicate of proposition) and extension (specification of items to which the predicate refers). This has been substantiated by empirical evidence. For example, Piaget and Inhelder (1964) carried out a study in which the child was asked to reproduce a row of five blue circles interspersed with three red squares. The younger children tended to concentrate their attention on one property at a time (form or colour) while neglecting the other properties. As a result, they were led to make incorrect reproduction of the given row of the model. In the second stage, the child has no problem reproducing the rows he is shown, but is not able to reverse the order of "all" and "some"; he clearly sees that some red objects are squares in a given row of red squares and blue circles. He cannot, nevertheless, grasp that all the squares are red. To the child of this age or stage, the proposition "some reds are squares" is interpreted to mean "some squares are reds". This is an error of intension.

Piaget (1964) and other researchers have asked children what they understand by "some" and responses are varied and interesting. To most young children no clear difference is discerned between "some" and "all"; for all they know, they are equivalent, if not identical. "Some" may be used in reference to one or two objects, if the set is small. When the set of objects is large, it is used in reference to four or five objects. Thus clearly indicating that as far as the child is concerned, he has no concise idea of extension of "some" in relation to "all". In general, the preoperational child finds it difficult to deal with part-whole relations (Elkind, Anagnostopoulou & Malone, 1970). It is only when the child has acquired this basic understanding that he is able to deal with class inclusion adequately and successfully.

Thematically, it can be deduced that an understanding of part-whole relations is an essential component of class inclusion. A similar theme (Luria, 1966; Das et al, 1975, 1979) dominates as an essential characteristic of simultaneous synthesis. Hence, the rationale for conceptualizing a relationship between Das' model and class inclusion. In all reasons given for the poor performance in class inclusion, no model has been advanced as a broad explanatory device. It is proposed in this study that Das' model of information processing with particular emphasis on simultaneous synthesis may contribute to a better understanding of children's performance in class inclusion and other Piagetian tasks.

Chapter IV

THEORETICAL LINKS

In this chapter, various modes of information processing will be examined in the light of simultaneous-successive synthesis. Following this, the rationale for assuming a relationship between Piaget's theory of cognitive development and Das' model of simultaneous-successive synthesis will be reiterated.

In the past (Tyler, 1978) cognitive psychology, in general, has paid very little attention to individual differences in information processing. Yet research (Tyler, 1978) has shown that what may be crucial to cognitive abilities or problem solving may be the strategies, cognitive styles and controlling processes used in manipulating information rather than capacities, speeds or sensitivity of mental components.

Galton (1883) and Marks (1973) have proposed that there are two modes of processing information: visualizaton and verbalization and that visualizers may be less competent as verbalizers or vice versa. For example, Galton demonstrated that most scientists of his time were poor visualizers since they were more able to recall the words symbolizingwhat they had perceived than the actual objects. Similarly, Paivio (1971) in an extensive review of literature, has shown that there are two modes of information processing, namely, visual and verbal. He has argued that both modes are used, although in some cases people indicate a preference for one mode over the other. Das et al (1975) note that an examination of the imagery and verbal learning work would lead to the conclusion that simultaneous synthesis is symmetric, that is, one has accessibility to an object from different views. On the other hand, Das notes that successive synthesis is asymmetric, meaning that one has access to an object in only one direction.

As regards cognitive styles, Witkin (1977) has suggested that conservation tasks call for one's ability to overcome the immediate perceptual visual features, and as such, it involves restructuring and the imposition of structure where there is none. According to Witkin, a field independent cognitive style is characterized by its analytical and restructuring quality. Hence, it has been demonstrated (Grippin, Ohmacht and Clark, 1973; and Pascual-Leone, 1969) that field independent subjects perform better in conservation tasksthan their counterparts, the field dependents. Interestingly it has also been shown that field independence loads on spatial organization (Witkin, 1977). Moreover, a study by Heemsbergen (1979) has shown that field independence correlates with simultaneous synthesis. Luria (1966) argues that spatial organization is a major component of simultaneous synthesis.

Simultaneous and successive processes are also related to Jensen's theory. Jensen (1970) has identified two modes of information processing called memory and reasoning or levels 1 & 11. By definition:

> Level 1 ability is essentially the capacity to receive or register stimuli, to store them, and later to recognize, or recall the material with a high degree of fidelity.... It is characterized by the lack of any need of elaboration, transformation or manipulation of the input in order to arrive at the output. Level 11 ability ...is characterized by transformation and manipulation of the stimulus prior to making the response (Jensen, 1970a, pp. 155-156).

Though Das (1973) rejects Jensen's interpretation, the two models have a lot in common. The relationship between the two models is such that some of Jensen's findings are used for supporting Das' model. To this end, Jarman notes: "A direct interpretation of his results is that the factors (Level 1 & 11) represent successive and simultaneous synthesis respectively" Jarman, 1978, p. 262). Jarman, however, does not believe that the two models can be used interchangeably, but holds that simultaneous-successive synthesis is a more parsimonious model. He states:

> When examined in terms of its essential internal assumptions, the theory of Level I-II abilities can be reinterpreted and placed in a broader perspective. Simultaneous-successive synthesis appears to be the best model for this purpose. (Jarman, 1978, p. 267).

It is also interesting to note that Smith's (1964) concept of spatial ability, defined as one's ability to perceive and retain in mind spatial patterns as an organized whole in contrast to the ability to switch attention from one item to another when perceived in temporal succession, resembles Das' concept of simultaneous synthesis. Both Jensen's levels of mental ability and Smith's concept of spatial ability, Molloy (1973) contends, are similar phenomenon. Smith's concept has been related to Gelb's (Molloy, 1973) concept of synopsis, which according to Luria (1966) is similar to simultaneous synthesis.

Comparing verbal-sequential strategies and spatial-visual strategies (Jarman, 1975), the latter which could be equated to simultaneous synthesis, is more dominant and more effective in reasoning tasks involving syllogism such as A is larger than B; C is smaller than B; which is largest (Clark, 1969a, 1969b, 1971, 1972; Huttenlocher & Higgins, 1972; Jones, 1970). Kirby's (1976) investigation indicated a significant relationship between simultaneous synthesis and spatial ability and that simultaneous synthesis is an important strategy in spatial ability tasks.

According to Luria (1966a, 1966b) and Das et al (1975), transitive reasoning or syllogisms as well as comprehending and forming superordinate relationships, which are typical of Piagetian cognitive developmental psychology, are best served by simultaneous synthesis. In reference to Koh Blocks, Luria (1966b) argues that a person who approaches it simultaneously is likely to outperform a person who approaches it successively. The emphasis being that the strategy one uses is crucial to successful performance on a given cognitive task (Krywaniuk & Das, 1976).

Tuddenham (1970) has demonstrated that people who have high spatial ability perform better on Piagetian tasks than those who do not. In this paper, it has been argued that simultaneous synthesis commands a conceptual relationship with spatial ability. It has also been reported that it has been empirically established that simultaneous synthesis and spatial ability are related (e.g. Kirby, 1976; Heemsbergen, 1979). It will also be recalled that in Chapter I, it was argued that the process involved in solving Piagetian tasks is characteristic of simultaneous synthesis.

According to Piaget (1941), preoperational thought is capable of only linking in a sequential order successive actions or perceptual states with which the child may be dealing. It is like a slow-motion film in which static frames are represented in succession without displaying a simultaneous and all-encompassing purview of all the frames. Concrete operational thought, on the other hand, is capable of achieving a simultaneous grasp of the whole. In a single brief moment, Piaget further argues, concrete operation thought is capable of recalling the past, representing the present and simultaneously anticipating the future. It is significant to note that the process involved in concrete operational thought is akin to what holds true in Das' simultaneous synthesis. Similar conceptual links have been noted in the processes involved in conservation of liquid, class inclusion and transitive inference.

In view of this, it was proposed that Piaget's theory of cognitive development could very well be examined from Das' model of information processing as an alternative approach to its predominantly content-oriented approach. In this context, it was not unreasonable to argue that people who predominantly process information simultaneously would perform better in conservation, transitive inference and class inclusion than those who predominantly process information successively.

Chapter V

STATEMENT OF PROBLEM AND HYPOTHESES

For years, psychologists have examined children's cognitive development in terms of whether or not they have acquired certain cognitive concepts such as conservation, object permanence, propositional logic. Hardly any studies have seriously concerned themselves with the process involved in achieving these cognitive skills. To this end, a number of psychologists have advocated that the content-approach be given way to a more process-oriented approach (Bruner, 1975; Youniss, 1975; McNemar, 1964; Thayer et al., 1978). A few studies have been conducted in response to this legitimate concern, and have shown that indeed one's strategy of information processing influences his performance on a given number of cognitive tasks (Bruner, 1964; Pascuall-Leone, 1969).

The purpose of this study was to examine Das' model as to whether or not one's mode of information processing would influence his success in tasks such as conservation, transitive inference, and class inclusion. Conceptually, there is enough evidence to indicate that Das' model of successive-simultaneous synthesis may contribute to our understanding of subjects' performance on Piagetian tasks. Specifically, it was evident that a person who predominantly processes information simultaneously stands a better chance of performing satisfactorily on Piagetian cognitive tasks.

In view of this, it was hypothesized that"

1. Simultaneous processors will perform in conservation, transitive inference, and class inclusion significantly better than successive processors.

2. Those who are high in both simultaneous and successive synthesis will perform significantly better in conservation,

transitive inference, and class inclusion than those who are low in both modes.

As secondary hypotheses, it was predicted that:

3. Due to developmental change, the older subjects will perform better on simultaneous synthesis tasks than younger subjects (e.j. Grade ones will perfo[illegible] than kindergarteners, and g[illegible] will perform better than both g[illegible] and kindergarteners).

4. The [illegible]ce of the three age groups on [illegible] tasks will be significantly different. grade ones will outperform kindergarteners in conservation, transitive inference, and class inclusion; secondly, grade twos will outperform both kindergarteners and grade ones in all three tasks.

Chapter VI

METHOD

Sample:

The sample of this study consisted of 94 males and 84 females, thus making a total of 178 subjects. On the basis of grades, there were 60 kindergarteners, 60 grade ones and 58 grade twos. These subjects were randomly selected from four randomly chosen schools operated by the Edmonton Separate School Board. The age level of the subjects ranged from 4.11-9.1 years and the mean age was 6.3. Table I shows the distribution of subjects according to grades and mean age. These subjects were chosen to constitute a single sample rather than three distinct groups. The rationale for this selection was based on neo-Piagetian literature which reveals that concrete operational thought emerges between the ages of 4½ and 8 years (Gelman, 1978). As a result of choosing such subjects, it was expected that there would be maximal variability on their performance on Piagetian concrete operational tasks. Brainerd (1973) used a similar sample in his study of concrete operational concepts.

In the analysis of factor loadings and factor scores of simultaneous and successive synthesis tests, two subjects were dropped because they did not complete all the tasks. Similarly, in the investigation of the relationship between the two sets of tasks, Piagetian and Das', 172 subjects were used; six had to be dropped because they did not do all the tasks.

Procedure:

The researcher sent an application to the Edmonton Separate School Board in December, 1979 asking for their permission to collect data from their school system. The application was approved on condition that the researcher consulted the respective school principals for their final approval. This was done towards the end of January, 1980.

TABLE 1

DISTRIBUTION OF SUBJECTS ACCORDING TO SEX, GRADE, AGE RANGE, AND MEAN AGE

	Kindergarteners	Grade 1	Grade 2	
Number of Cases	60	60	58	
Age Range	4.11-5.11	5.11-7.9	6.9-9.1	
Mean Age	5.4	6.5	7.3	
Males	30	35	29	
Females	30	25	29	
Total Number of Subjects				178
Grand Mean Age				6.3

All the principals consulted in the four different schools agreed to co-operate in providing the required subjects. Collection of data commenced towards the end of March and was completed at the end of May, 1980.

Seven tests: Raven's Progressive Matrices (Raven, 1965), Figure Copying (Ilg & Ames, 1964), Serial Recall, Digit Span, Class Inclusion, Transitive Inference and Conservation of Liquid (Piaget, 1952) were administered on an individual basis with the exception of Figure Copying which was administered in a group of fifteen subjects at a time. There was no time limit for any one of the seven tests, and as such, subjects worked on them until they completed them. Generally, each subject appeared for one test per day, which meant it took about seven days for each child to complete all the tests. The researcher administered all the tests.

The places where the tests were administered varied from school to school and at times from day to day. Generally, the testing took place either in the library or in an office assigned to the researcher. The atmosphere of the environment was conducive to testing since there were no apparent distractions.

Measuring Instruments:

A. Simultaneous and Successive Synthesis Tests

Four tests (Progressive Matrices, Figure Copying, Serial Recall and Digit Span) were used for assessing simultaneous and successive synthesis. The first two were used for measuring simultaneous synthesis, while the remaining two were used for measuring successive synthesis.

Raven's Progressive Matrices:

The subject is shown an incomplete geometrical drawing which he is required to complete by selecting an appropriate drawing from one of the six small drawings displayed on the same page. For each correct choice, the subject is given a score of one, the highest score is 36 points.

Serial Recall:

This test consisted of 16 lists of words. These were broken into three categories: the first consisted of four words, the second one consisted of seven words, and the third category consisted of nine words per list. The experimenter read aloud one list at a time and then asked the subject to recite the list of words in the same order he had heard it. For each word correctly recalled in the given sequence, the subject was given a score of one point, the highest score is 96 points.

Digit Span:

This test consists of numbers whose digit span ranges from three to nine digits. The experimenter says the series aloud and then asks the subject to repeat it in the same order. For each series correctly recalled a score of one is allotted for each digit. The total score is 42 points.

B. Piagetian Tests:

Three tests were used for measuring concrete operational thought. To assess the presence of class inclusion concept, a subject was presented with a set of five fruits consisting of two plastic apples and three plastic bananas. Before asking the subject the designated questions, the experimenter ensured that the subject understood the meaning of "fruit". This was done by asking the subject to identify the objects before him both individually and collectively. He was also asked to mention other fruits he knew. He was then asked the following questions: "Are there the same number of bananas and fruits? Are there more bananas than fruits? Are there more fruits than bananas? Why?" If the subject said there were more bananas than fruits, he scored a zero; if he said the fruits were more, but did not justify his answer, he scored one point. On the other hand, if the subject was able to give the correct response and an appropriate justification, he scored two points and was considered to have the concept of class inclusion. Following this, the subject was shown a set of eight plastic animals consisting of three horses and five cows. Similar questions as in the case of fruits were asked and the scoring was identical.

Two sets of sticks were used for measuring the presence of transitive inference concept. The first set consisted of three sticks of equal length labelled A, B, C (the subject was not told that they were of the same length). The subject was shown the three sticks in such manner that he could not tell that they were of equal length. This was done by placing the sticks far apart and at different resting positions. The sticks were all removed from sight after which the experimenter brought back sticks A and B. The subject was asked to examine the two sticks to see whether they were of the same length. If the answer was positive, stick A was removed and replaced by stick C. Again the subject was asked to compare the two sticks. If the answer was correct, the experimenter removed stick B and brought back stick A. Holding the two sticks far apart (about 2 feet), the experimenter asked the subject whether one of the sticks was longer than the other, or they were the same length. If the response was that they were the same, the subject was asked to justify his answer. If the subject said one of the sticks A or C was longer than the other, he was given a zero score and no justification was asked for. If he said they were the same, he was given one point; if he gave a correct response as well as a justification (an appropriate one), he scored two points and was considered to have the concept of transitive inference. Following this, the subject was shown a set of three sticks (A, B, C) of unequal length. A similar procedure as in the first set of sticks was used for assessing the concept in question.

Two bottles filled with water and three empty beakers were used for assessing the presence of conservation concept. The subject was first shown two beakers of equal size and asked to examine them whether or not they were equal in size. Following this, he was asked to fill one of the beakers with water, while the experimenter filled the other. He was then asked whether the amount of water in the two beakers was the same. All the subjects got this without any problem and if they did not, the experimenter helped them to get it correct. The subject was then asked to pour the water from his beaker into a wider and longer beaker, after which he was asked whether the amount of water was still the same or one of the beakers had more water than the other. If he said that the amount of water was still the same, he was given a score of one. On the other hand, if [illegible] id one of the glasses had more water than the other, he was given a zero and no further questions were asked. Two points were given to a subject who gave a correct response as well as a justification. Such a subject was considered to have attained the concept of conservation.

On the three Piagetian tasks the subjects fell into three categories, namely, those who did not have the concept in question, those who were transitional and those who had the concept in question. Anyone who scored a zero fell in the first category, those who scored a one fell in the second category, while those who scored two points fell in the third category.

Research Design

Two principal statistical techniques were employed in the investigation of the four research hypotheses. The first two hypotheses were tested by means of a 2x3 ANOVA with repeated measures followed by Scheffe multiple comparison of means.

Secondly, a one-way ANOVA with repeated measures was used for testing the fourth hypothesis. The third hypothesis was tested by means of a one-way ANOVA.

Chapter VII

ANALYSIS OF DATA

In this chapter, the statistical technique used for investigating the research hypotheses as well as the results thereof will be described. The chapter is divided into six sections based on the number of investigations made. The first section consists of a brief account of factor analysis of the scores obtained on the four tests measuring simultaneous and successive synthesis. The second section deals with the major hypothesis which predicts that simultaneous synthesis processors compared to successive processors will perform significantly better on Piagetian tasks (class inclusion, transitive inference, and conservation of liquid). This is followed by the analysis of the second hypothesis which predicts that those who are high in both simultaneous and successive synthesis will outperform those who are low in both modes of information processing. The fourth section deals with the analysis of the third hypothesis predicting a significant difference in simultaneous synthesis skills among the three age groups. The fifth section is focussed on the differences among the three age groups in their performance on Piagetian tasks. In the sixth section, the writer examines the level of difficulty of the three Piagetian tasks for each age group and all the groups combined.

SECTION I

The raw scores of 176 subjects were submitted to a principal component analysis to determine whether they would load on the two factors of Das' model, namely, simultaneous and successive synthesis. These two factors, as other researchers (e.g. Das, 1972; Jarman, 1975; Kirby, 1976) have observed in the past, emerged. Raven's Progressive Matrices and Figure Copying loaded on simultaneous synthesis, whereas Serial Recall and Digit Span loaded on successive synthesis. Table II shows how each test loaded on the two factors.

The loadings of these tests on the respective factors, simultaneous and successive synthesis, are significant to Das' model in that they further affirm the validity of his claims as well as the reality of the existence of the two modes of information processing.

From the factor loadings, factor scores were generated for both simultaneous and successive synthesis. On the basis of these factor scores, a median split was used for dividing subjects into four groups. The first group consisting of forty-two subjects, was made up of those who were high in simultaneous synthesis but low in successive synthesis. The second group consisted of forty subjects who were high in successive synthesis but low in simultaneous synthesis. In the third group, there were forty-four subjects who were high in both simultaneous and successive synthesis, whereas the fourth group consisted of forty-six subjects who were low in both modes of information processing. The median score for simultaneous synthesis was 48 , whereas for successive synthesis, it was 49 . Those who scored above the median scores were considered high in the respective mode of information processing, whereas those who scored below the median were considered low in that mode.

In summary, factor analysis was performed on the raw scores which resulted in the factor loadings on the two modes of Das' model. From the factor loadings, factor scores were generated for each subject and for the entire sample. On the basis of the factor scores, subjects were divided by means of a median split into four groups.

SECTION II

The primary purpose of this study was to investigate whether a relationship exists between Das' model of information processing and Piaget's theory of cognitive development. On

TABLE II

ROTATED (VARIMAX) MATRIX FOR SIMULTANEOUS AND SUCCESSIVE SYNTHESIS

N 176

	h^2	1	2
Figure Copying	0.739	0.817	0.268
R.P. Matrices	0.788	0.869	0.179
Digit Span	0.843	0.143	0.907
Serial Recall	0.761	0.350	0.799
% com. var.		50.030	49.970
% Tot. var.		39.151	39.105

the assumption that such a relationship exists, it was hypothesized that there would be a distinction in performance between simultaneous processors and successive processors. This distinction, it was predicted, would be in favour of the predominantly simultaneous processors who would outperform the predominantly successive processors on all the three Piagetian tasks, namely, class inclusion, transitive inference, and conservation of liquid. To verify this hypothesis, the null hypothesis was tested by means of a 2x3 ANOVA with repeated measures as shown in Table III.

From Table III, it was clear that the main effects on level A were significant (F=32.32, df=1, 81, p=0.001). In view of this, the null hypothesis that the means of the two groups would be nonsignificant was rejected. The research hypothesis predicting a distinction in performance between the two groups was strongly supported.

Table III also shows that the B main effects were significant (F=22, df=2, 160, p=0.01) indicating that the tasks' level of difficulty was not the same. Further it indicates that the interaction between modes of information processing and Piagetian tasks was significant (F=3.75, df=2, 160, p=0.02). This would indicate that the differences between the two groups varied from task to task.

Table IV shows the means and standard deviations of the two groups on Piagetian tasks. To test which of the means were significantly different, Scheffe post hoc analysis was performed as shown in Table V.

Evidently, simultaneous processors outperformed successive processors in all the three Piagetian tasks. Their statistically significant performance was quite outstanding in both class inclusion and transitive inference as it was significant beyond alpha=0.001. The difference between the two groups in conservation was less pronounced, but significant at alpha 0.09. This is an acceptable level due to the fact that Scheffe multiple comparison is quite rigorous (Ferguson, 1976; Winer, 1971; Scheffe, 1959). In addition, a "t" test was used to test the mean difference on conservation. It was significant at alpha 0.05.

TABLE III

A SUMMARY OF A 2x3 ANOVA WITH REPEATED MEASURES FOR SIMULTANEOUS AND SUCCESSIVE PROCESSORS ON PIAGETIAN TASKS

N 172

Source of Variation	SS	DF	MS	F	P
Between Subjects	84.3	81			
Simult./Success.	24.3	1	24.3	32.4	0.001
Subjects Within Groups	.60	80	.75		
Within Subjects	88.0	164			
Piagetian Tasks	18.3	2	9	22	0.01
AxB Interaction	3.1	2	1.5	3.7	0.02
BxSub Within Groups	66.3	160	0.4		

TABLE IV

MEANS AND STANDARD DEVIATIONS OF SIMULTANEOUS AND SUCCESSIVE PROCESSORS IN CLASS INCLUSION, TRANSITIVE INFERENCE, AND CONSERVATION OF LIQUID

		Class Inclusion		Transitive Inference		Conserv.	
	N	Mean	S.D.	Mean	S.D.	Mean	S.D.
Simu. Processors	42	1.548	0.74	1.500	0.63	0.714	0.97
Succ. Processors	40	0.800	0.72	0.675	0.53	0.400	0.67

TABLE V

SCHEFFE MULTIPLE COMPARISON OF MEANS IN CLASS INCLUSION, TRANSITIVE INFERENCE, AND CONSERVATION OF LIQUID FOR SIMULTANEOUS AND SUCCESSIVE PROCESSORS

Task	Mean Difference	Sig.	P
Class Inclusion	0.75	Yes	0.01
Transitive Inference	0.83	Yes	0.01
Conservation of Liquid	0.31	Yes	0.09

Degrees of Freedom 2, 240

In this section the data analysis of the first and primary hypothesis of this study has been reported. In view of the results of the analysis, the research hypothesis that simultaneous synthesizers would outperform successive synthesizers has been strongly supported. In the investigation of individual tasks for the two groups, simultaneous processors outperformed their counterparts in every Piagetian task.

SECTION III

Since it was apparent (Das, 1979) that there would be a group of subjects who would be high in both modes of information processing, and another group of subjects who would be low in both modes, it was hypothesized that the latter would be outperformed by the former. To investigate this hypothesis, a 2x3 ANOVA with repeated measures was employed. The results are shown in Table VI.

The main effects for A level which consisted of those who were high in both simultaneous and successive and those who were low in both modes were significant (F=27.8, df=1, 88, p=0.001) indicating, as it did, that the two groups' performance was significantly different on the three Piagetian tasks. It follows that the null hypothesis was rejected, while the research hypothesis was supported and accepted. The main effects for level B were also significant (F=47, df=2, 176, $p<0.01$) which shows that the three tasks were not of equal difficulty.

Table VII shows the means and standard deviations of the two groups on the three Piagetian tasks. The means of those who were high in both simultaneous and successive synthesis were consistently higher in the three tasks than those who were low in both modes of information processing. A post hoc analysis using Scheffe's multiple comparison was used to test the difference on each of the tasks. The results (Table VIII) show that the difference in means for the two groups on the three tasks was statistically significant.

In summary, the analysis of data pertaining to the second

TABLE VI

A SUMMARY OF A 2x3 ANOVA WITH REPEATED MEASURES FOR THOSE WHO WERE HIGH IN BOTH SIM. AND SUCC. AND THOSE WHO WERE LOW IN BOTH SS ON THREE PIAGETIAN TASKS

Source of Variation	SS	DF	MS	F	P
Between Subjects	69.5	89			
A Main Effects	16.7	1	16.7	27.8	0.001
Subjects With Groups	52.8	88	0.6		
Within Subjects	128.0	180			
B Main Effects	44.8	2	22.4	47.4	0.01
AxB Interaction	0.0	2	0.0	0.0	0.99
BxSub. With Groups	83.2	176	0.5		

TABLE VII

MEANS AND STANDARD DEVIATIONS OF THOSE WHO WERE HIGH IN BOTH SS AND THOSE WHO WERE LOW IN BOTH SS IN CLASS INCLUSION, TRANSITIVE INFERENCE AND CONSERVATION OF LIQUID

	High Sim-Succ.		Low Sim-Succ.	
	Mean	S.D.	Mean	S.D.
[illegible]ss Inclusion	1.545	0.73	1.065	0.83
Transitive Inference	1.182	0.76	0.674	0.63
Conservation	0.568	0.89	0.065	0.33
Number of Cases	44		46	

TABLE VIII

SCHEFFE MULTIPLE COMPARISON OF MEANS FOR THOSE WHO WERE HIGH IN BOTH SS AND THOSE WHO WERE LOW IN BOTH SS ON CLASS INCLUSION, TRANSITIVE INFERENCE AND CONSERVATION

Task	Mean Difference	Sig.	P.
Class Inclusion	0.48	Yes	0.01
Transitive Inference	0.50	Yes	0.01
Conservation of Liquid	0.50	Yes	0.01

Degrees of Freedom 2, 264.

hypothesis led to the rejection of the null hypothesis and acceptance of the research hypothesis that those who were high in both modes of information processing would perform significantly better than those who were low in both modes. A post hoc analysis indicated that the observed difference was stable in all three Piagetian tasks.

SECTION IV

Jarman (1978) has argued that older subjects are more likely to process information more simultaneously than younger subjects. In his view, simultaneous synthesis distinguishes between younger subjects and older subjects in terms of their performance in simultaneous tasks more than it would be the case with successive synthesis.

In view of this, it was hypothesized that there would be a difference in performance among the three age groups. That is to say, grade ones would perform significantly better than kindergarteners, whereas grade twos would perform significantly better than both groups. To investigate this hypothesis, a one-way ANOVA was used. The results, shown in Table IX, indicate significant differences ($F=76.7$, $df=2$, 173 $p<0.001$). Scheffe tests (Table X) show that without exception, the older subjects performed significantly better than the younger subjects ($F=21.8$, 76.5, 16.8; $df=2$, 173, $p<0.001$). A similar analysis was done for successive synthesis but the results were nonsignificant.

The purpose of this section was to investigate the difference of age groups in their performance in simultaneous synthesis tasks. As predicted, older subjects outperformed younger subjects. This led to the rejection of the null hypothesis and the acceptance of the research hypothesis.

SECTION V

In view of Piaget's theory, it was expected that there would be significant differences among the age groups due to maturation. A three by three ANOVA (grade by task) with

TABLE I.X

A SUMMARY [illegible] ONE-WAY ANOVA FOR KINDERGARTENERS, GRADES ONES AND TWOS IN SIMULTANEOUS SYNTHESIS SKILLS

Source of Variation	SS	MS	DF	F	P
Groups	8270.2	4135[illegible]	2	76.7	0.001
Error	9329.0	53.9	173		

TABLE X

SCHEFFE MULTIPLE COMPARISON OF MEANS FOR KINDERGARTENERS AND GRADE ONES AND TWOS IN SIMULTANEOUS SKILLS

Grade	Mean Diff.	Error	DF1	DF2	F	P
K-2	79.8	3.7	2	173	21.8	0.0[illegible]
K-3	282.[illegible]	3.7	2	173	76.6	0.001
2-3	61.9	3.7	2	173	[illegible]6.8	0.001

repeated measures was used for examining this hypothesis. Table XI displays the results of the analysis.

Table XI indicates a significant interaction between age groups and tasks. The resulting cell means are plotted in Figure II. Scheffe contrasts (Table XII) indicated that both grade ones and grade twos outperformed kindergarten subjects in class inclusion. There was no difference between grade ones and grade twos.

On transitive inference, grade twos were significantly different from grade ones and kindergarten subjects. The latter two groups were not different from each other.

Finally, on conservation of liquid, the results were the same as transitive inference with grade twos being significantly superior to grade ones and kindergarteners.

Though the overall hypothesis was strongly supported, the critical age appeared to be different for different tasks. There was no case in which older subjects were significantly outperformed by younger subjects. In this context, Piaget's contention about the role of maturation in cognitive development remains intact.

In summary, the hypothesis that the various age groups would differ significantly was supported. A post hoc analysis, however, showed that this difference held true with some tasks for certain groups of subjects.

SECTION VI

Though no hypothesis was formulated regarding the efficiency of each group on each one of the tasks, Scheffe tests were done to this effect as shown in Table XIII. The rationale for this is that there has been a controversy as to which of the concrete operational concept predates the other (Piaget, 1952; Brainerd, 1973; Winer, 1980).

The treatment means for kindergarteners on the three Piagetian tasks were significantly different. This meant that the subjects did not perform each one of the three tasks at the same level of efficiency. In other words, expectedly,

TABLE XI

A SUMMARY OF A 3x3 ANOVA WITH REPEATED MEASURES FOR KINDERGARTENERS, GRADE ONES AND TWOS IN CLASS INCLUSION, TRANSITIVE INFERENCE AND CONSERVATION OF LIQUID

Source of Variation	SS	DF	MS	F	P
Between Subjects	155.2	172			
A Main Effects	57.3	2	28.7	49.4	0.01
Sub With Groups	97.7	170	0.6		
Within Subjects	218.0	346			
B Main Effects	60.3	2	30.1	71.1	0.01
AxB Interaction	12.1	4	3.0	7.1	0.01
BxSub With Groups	144.2	340	0.4		

FIGURE II

A GRAPH SHOWING MEANS OF KINDERGARTENERS, GRADERS ONES, AND TWOS IN CLASS INCLUSION, TRANSITIVE INFERENCE, AND CONSERVATION

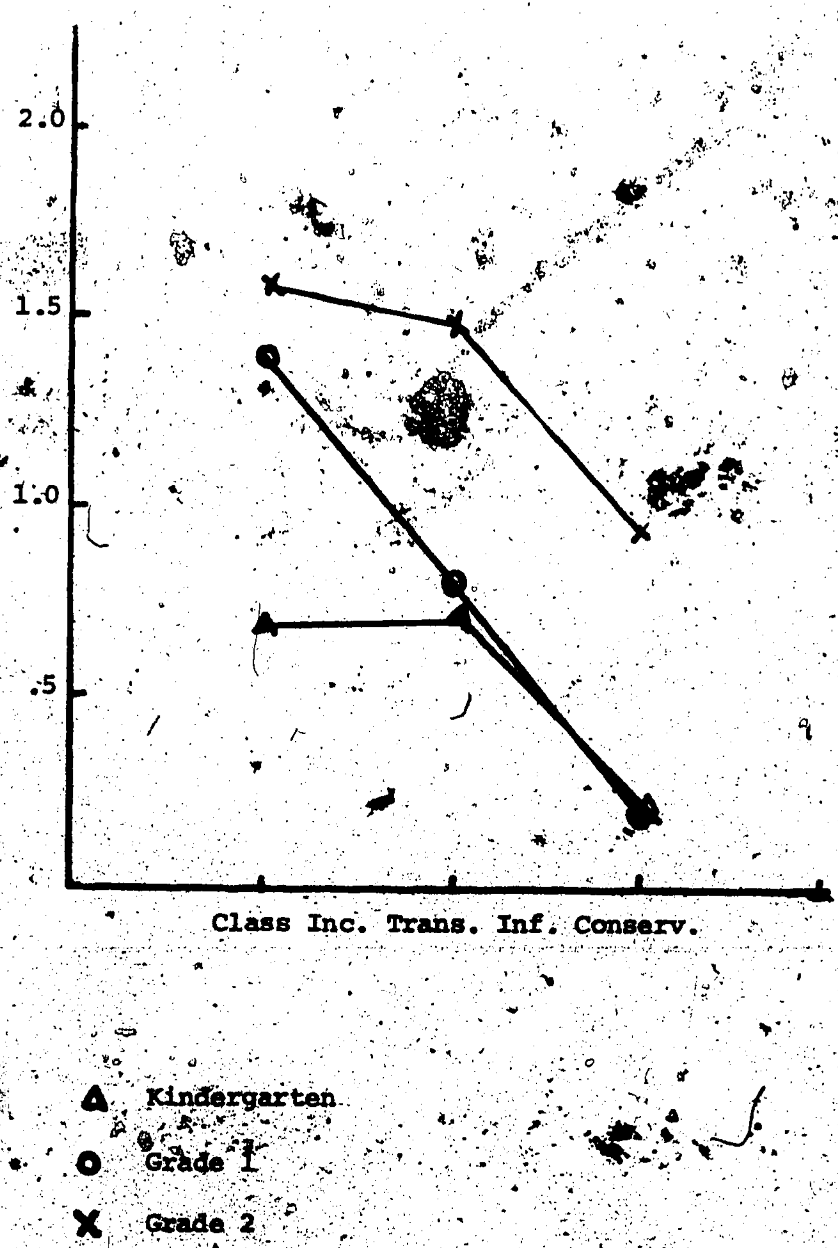


TABLE XII

SCHEFFE MULTIPLE COMPARISON OF MEANS FOR KINDERGARTENERS, GRADES I AND II IN CLASS INCLUSION, TRANSITIVE INFERENCE, AND CONSERVATION OF LIQUID

Task	Grades	Mean Difference	Sig.	P.
Class I	K-1	.701	Yes	0.01
	K-2	.829	Yes	0.01
	1-2	.128	No	
[illegible]ans. I	K-1	.001	No	
	K-2	.723	Yes	0.01
	1-2	.725	Yes	0.01
Conserv.	K-1	.011	No	
	K-2	.822	Yes	0.01
	1-2	.832	Yes	0.01

Degrees of Freedom 2, 510

TABLE XIII

SCHEFFE MULTIPLE COMPARISON OF MEANS FOR CLASS INCLUSION, TRANSITIVE INFERENCE AND CONSERVATION

Subjects	Cases	Contrast	Difference	Sig.	P.
Kinderg.	56	Class I. vs. Trans. I	0.03	No	
		Class I. vs. Conserv.	0.57	yes	0.01
		Trans. I vs. Conserv.	0.60	Yes	0.01
Grade One	60	Class I vs. Trans. I	0.66	Yes	0.01
		Class [illegible] Conserv.	1.28	Yes	0.01
		Trans. I vs. Conserv.	0.61	Yes	0.01
Grade Two	57	Class I vs. Trans. I	0.07	No	
		Class I. vs. Conserv.	0.57	Yes	0.01
		Trans. I. vs. Conserv.	0.50	Yes	0.01
All Subjects	173	Class I. vs. Trans. I	0.24	Yes	0.01
		Class I. vs. Conserv.	0.82	Yes	0.01
		Trans. I. vs. Conserv.	0.58	Yes	0.01

Degrees of freedom 2, 510

some tasks were more difficult than others. For example, conservation was the most difficult; it was more difficult than transitive inference and class inclusion. Consequently, the subjects performed less efficiently in conservation than in both transitive inference and class inclusion. On the other hand, there was no significant difference between the subjects means in both class inclusion and transitive inference; indicating that kindergarteners performed these tasks at the same level of efficiency.

Similarly, the treatment means for grade ones were significantly different. Class inclusion was performed at the highest level of efficiency, whereas conservation was performed at the lowest level of efficiency. The mean difference between class inclusion and transitive inference was also significant. Transitive inference was more difficult than class inclusion, and as a result, the level of efficiency for this task was lower than that of class inclusion. A comparison between transitive inference and conservation indicated that the latter was more difficult than the former. The level of efficiency for transitive inference was higher than that for conservation.

Another analysis in this section consisted of grade twos. As it was the case with the first two groups, the treatment means for this group were significantly different. Both class inclusion and transitive inference were performed at an equal level of efficiency, that is, neither one of them was more difficult than the other. On the other hand, class inclusion was performed at higher level of efficiency than conservation. Similarly, transitive inference was performed at a higher level of efficiency than conservation.

Finally, all the three age groups were combined as a single group to examine their efficiency in the three tasks. This was done for the purpose of comparing Brainerd's findings in which he used a similar sample (kindergarteners, grades one and two) and the findings of this study. The order of difficulty in this was as follows: conservation→transitive inference→class inclusion, whereas the converse was the level efficiency at which the subjects performed in the three tasks. That is, class inclusion was performed at the highest level of efficiency followed by transitive inference, whereas conservation was performed at the lowest level of efficiency. As it was the case with individual groups, conservation emerged as the most difficult task, whereas class inclusion was the easiest.

In this chapter, the author has described the results of data analysis. In summary, all the four research hypotheses were strongly supported beyond alpha=0.01. Specifically, it was empirically demonstrated that: simultaneous processors were better at Piagetian tasks than successive processors. Similarly, those who were high in both simultaneous and successive synthesis outperformed those who were low in both modes of information processing. Thirdly, older subjects performed better on simultaneous synthesis tasks than younger subjects. Fourthly, older subjects performed better than younger subjects on Piagetian tasks. Fifthly, it was observed that the level of difficulty for the three tasks was not the same; class inclusion being the easiest, whereas conservation was the most difficult.

In the next chapter, the author will focus on the discussion of the results and their implications.

Chapter VIII

DISCUSSION

The principal concern of this research was to investigate the relationship between Das' model of simultaneous-successive synthesis and Piaget's third stage of cognitive development, concrete operation. The rationale for conceptualizing such a relationship was derived from the related literature. In short, the nature of simultaneous synthesis as a process by which a person processes holistically with emphasis on his ability to visualize the interrelationship of various components of a given object seemed quite compatible with the process involved in successful performance on Piagetian tasks such as conservation, transitivity and class inclusion. Secondly, it was observed that simultaneous synthesis is related to a number of theories that have spatial ability as an integral component. A review of the literature indicated that those who perform well on some of these tasks also perform well on Piagetian tasks. Thirdly, a number of psychologists have expressed their concern for an alternative to Piaget's approach of assessing cognitive development--the approach being content-oriented instead of process-oriented. Das' model seemed to be one possible solution to this legitimate concern.

Given the described conceptual relationship between Das' model and Piaget's theory of cognitive development, as well as the concern for a process-oriented approach to the assessment of cognitive development, the author hypothesized that simultaneous processors would perform significantly better on Piagetian tasks than successive processors. It was interesting to observe that this hypothesis was strongly supported. It was not only the overall performance of simultaneous processors that was superior to that of successive processors, but also the former's performance in each one of the Piagetian three tasks. It thus demonstrated that indeed the process involved in solving Piagetian concrete operational tasks is compatible with Das' model of simultaneous-successive synthesis.

In view of this, it is not unreasonable to argue that a person's ability to synthesize elements into whole simultaneous groups so that they are surveyable as well as one's understanding of relationships serve as a basic ingredient for successful performance on Piagetian concrete operational tasks.

It can be further argued that being predominantly a simultaneous processor assists one to decenter his attention when looking at a number of given objects such as may be the case in the conservation of liquid. In other words, one is able to conceptualize relations between and among objects and their different dimensions. Consequently, one is likely to reason that though beaker A is thin, it is nevertheless compensated by its height, or given that beaker B is short, it is compensated by its width. Such reasoning, as Piaget would argue, is likely to lead to the attainment of conservation concept.

Similarly, it could be argued that a simultaneous processor would find it easier, in terms of transitive inference, to look at objects symmetrically rather than asymmetrically; one is able to examine each object in light of both a direct and an inverse relational operation. In other words, one is able to perceive that an object has more than one relationship.

In terms of class inclusion, a simultaneous mode enables one to decompose classes from a superordinate level to a subordinate class, thus indicating reversibility and mobility of thought. It must be pointed out that this is only possible as a result of the subject's grasp of the relation between subclasses and their superordinate class. That is to say, an understanding of part-whole relations is essential for the attainment of class inclusion concept. This, as it has been pointed out earlier, is attainable with the aid of simultaneous synthesis skills.

In summary, it may be said that as a result of processing information simultaneously, one is capable of, in terms of concrete operational thought, achieving a simultaneous grasp of the whole so that he recalls the past, represents the present and simultaneously anticipates the future. This is quite a contrast from a predominantly successive processor who like a preoperational subject tends to link actions or perceptual states in a sequential manner without displaying a simultaneous and all-encompassing purview of all the frames (Piaget, 1941).

The present finding is in harmony with other findings such as Pascual-Leone (1969) who demonstrated that a field independent cognitive style is more appropriate for solving Piagetian concrete operational problems than a field dependent style. Similarly, the present study is in agreement with Tuddenham (1970) who argued and demonstrated that those who are high in spatial ability outperform those who are low in such ability. These findings are quoted here because it has already been argued that they are related to simultaneous synthesis. Furthermore, they are quoted because they fall within the same category, and that is information processing.

It is further relevant to note that the findings of this study lend support to those of Das and Cummins' (1978) in which it was shown that simultaneous processors outperformed successive processors in class inclusion. In conclusion, the two authors stated: "Simultaneous processing is clearly basic to the task of grasping the relationship between the superordinate and subordinate class" (Das and Cummins, 1978, 10).

Since a review of literature (Bickersteth, 1979; Das et al, 1979) revealed that there would be a group of subjects who would be high in both simultaneous and successive synthesis, and another group of those who would be low in both modes, it was hypothesized that the former would perform significantly better than the latter. The rationale for this hypothesis was that it was important for subjects to have the required process or strategy in adequate measure for their successful performance on Piagetian tasks. Secondly, it was conceived that two strategies are better than one, unless they are diametrically opposed. Thirdly, consistency demanded that wherever simultaneous synthesis existed, the chances were that it would be advantageous in the performance of Piagetian tasks. Fourthly, previous research (Das and Kirby, 1977) has shown that subjects who have both skills in adequate measure tend to perform better than those who do not.

As it was the case with the first hypothesis, the second hypothesis was also strongly supported. This held true in terms of the overall performance and individual tasks. It thus demonstrated the necessity and importance of the presence of appropriate strategies for one to succeed in any given cognitive task. This finding lends support to Bickersteth's (1979) study in which it was demonstrated that those who were high in both strategies performed better in categorization and syllogistic reasoning than those who were in high command of a single strategy. Similarly, this study extends the finding of Das and Kirby (1977) in which it was shown that those who were high in both strategies were better readers than those who were high in a single strategy. But this vein of argument held true only in the case of successive synthesis processors who were outperformed by both simultaneous processors and those who were high in both strategies. As regards simultaneous synthesis processors, there was no significant difference with those who were high in both modes. In this context, the successful performance of the subjects falling in this category was attributed to the subject's possession of simultaneous synthesis skills.

As a secondary hypothesis, it was predicted that there would be significant difference, in performance, among the three age groups in simultaneous synthesis skills. In other words, older subjects were expected to be more conversant with the use of simultaneous synthesis as a mode of information processing than the younger subjects. The rationale for such a hypothesis was derived from the related literature. According to Denney (1974) at the age of 6-9, children tend to predominantly process information syntagmatically and as they grow older, their predominant mode of information processing is that of paradigmatic. Pribram (1960) and Luria (1973) point out that paradigmatic processing is a function of simultaneous synthesis, whereas syntagmatic processing is generated by successive synthesis. Jarman (1978) argues that there is theoretical evidence to indicate that simultaneous processing may be superior and more effective than successive synthesis. This argument was only partially supported in an empirical investigation (Jarman et al 1980). On the other hand, it was observed that the rate of growth of simultaneous synthesis was relatively much higher than that of successive synthesis. This finding was borne out in the present study. The difference between the older and the younger subjects was significant in simultaneous synthesis, whereas such difference was not observed in successive synthesis. Though this was the case, theoretically one would have expected some difference due to developmental changes. That is to say, by virtue of their age, older subjects would have been expected to do better than younger subjects.

This finding raises an important theoretical question, and that is, are the two modes of information processing non-hierarchical and of equal status as Luria (1966) and Das et al (1975) have consistently claimed? In regard to hierarchy, both Luria and Das have not been supported by the present study, nor were they supported in Jarman's et al study (1980). In terms of status, their argument remains viable in the sense that there are some tasks that call for simultaneous or successive synthesis skills. In this context, using the former for the latter or vice versa would be unproductive. It must be stressed that the effectiveness and superiority of a strategy are not absolutes as they are relative. Each strategy, therefore, may be considered vital within its own right, when all other things are equal.

Piaget's theory (1941) has stressed the role of maturation in the attainment of higher levels of cognitive development. According to Piaget, the concrete operational stage is not in full operation until the age of 7-8 (based on the subjects tested). This claim has been contested by a number of researchers (e.g.Siegel, 1978; Gelman, 1978; Mehler & Bever, 1967) who have shown the presence of concrete operational thought as early as 4½ years of age. In view of the theory's claim and despite subsequent contention, it was hypothesized that there would be significant difference in concrete operational tasks performance among the three age groups. This hypothesis was strongly confirmed, thus confirming Piaget's stress on the role of maturation as well as other researchers' findings (Elkind, 1961; Youniss, 1975; Kiminyo, 1973). An analysis of individual tasks, however, revealed that in some tasks there was no significant difference between two age groups. For example, there was no significant difference between grades one and two in class inclusion, nor was there a significant difference between grade one and kindergarteners in conservation of liquid. Significant differences were observed in other tasks and groups. There were significant differences between grade one and kindergarteners as well as grade two and kindergarteners in class inclusion. Similarly, there were significant differences between kindergarteners and grade two and between grade one and two in conservation. In transitivity, both kindergarteners and grade ones were outperformed by grade twos. It was interesting to note that wherever a significant difference was observed, it was the older subjects who performed better than the younger ones. There was not a single incident where the converse held true. It was further interesting to note that there was no single incident where the three age groups performed at par in any one of the three tasks. In this light, Piaget's contention regarding maturation found strong support in this study. This observation cannot be mutually extended to Piaget's contenders.

Although there was no hypothesis formulated for the level of difficulty of the three tasks, this was investigated in this study. According to Piaget, the various concepts of concrete operation are attained in the following order: class inclusion → transitivity → conservation (Piaget, Inhelder, Szeminsha, 1960; Inhelder and Piaget, 1964). Lovell and Ogilvie (1961) observed that both conservation and transitivity emerged synchronously, thus supporting Piaget's contention. Similarly, Wohlwill (1968) and Smedslund (1964) observed that class inclusion emerges before conservation. Brainerd (1973), however, has contested Piaget's claim and those of neo-Piagetian literature. His contention is based on two studies: His first study consisted of two samples of American and Canadian subjects randomly drawn from grade twos. In the American sample, transitive inference emerged before conservation, whereas with the Canadian sample, the two concepts emerged simultaneously. In view of this discrepancy, the author states: "This discrepancy probably is due to some systematic influence of which the writer is unaware" (Brainerd, 1973, p. 111). He does speculate, however, that Canadian subjects could have been given instruction that accelerated their conservation, whereas the American sample might have been given instruction that might have facilitated their performance in transitive inference.

This study was followed by another study which consisted of American and Canadian samples of subjects randomly selected from kindergarten, grades one and two. The means of ages for the various age groups was: kindergarten, 5.4 years; grade one, 6.4 years; and grade two 7.10 years. The results were that grade twos outperformed kindergarteners and grade ones in transitive inference and conservation, and class inclusion. Similarly, kindergarteners were outperformed by grade ones in all the three tasks. Both conservation and transitive inference were equally difficult for grade twos, whereas for both kindergarteners and grade ones, conservation was more difficult than transitive inference. For K-1 and grade ones, the order of difficulty was as follows: transitive inference → conservation, but the same order did not hold true for grade twos. In conclusion, Brainerd makes two points of observation. In the first one he states: "This finding clearly is inconsistent both with predictions from Piagetian theory and existing neo-Piagetian literature" (Brainerd, 1973, p. 115). He further states: "Finally, the most persistent result of the present studies is that class inclusion emerges much later than either transitivity or conservation" (Ibid.).

According to the present study, the level of difficulty for each age group was as follows:

Kindergarteners: class inclusion ↔ transitivity →
conservation
Grade ones: class inclusion → transitivity →
conservation
Grade twos: class inclusion ↔ transitivity →
conservation
All subjects: class inclusion → transitivity →
conservation.

Contrary to Brainerd's claim, conservation emerged as the most difficult task of the three tasks for all groups. In support of Piaget, class inclusion was the easiest task for grade ones, whereas for grade twos and kindergarteners, it was at the same level of difficulty as transitive inference. For all subjects combined, class inclusion was the easiest followed by transitive inference, whereas conservation, again emerged as the most difficult task. The emergence of conservation as the most difficult task as shown by this study contradicts both Piaget's and Brainerd's claims. Both this finding and those of others are based on empirical evidence and yet they are inconsistent and contradictory. In this view, none of the researchers involved can claim infallibility. A compromise for these contradicting findings may be to state that the order in which these three concepts emerge is dependent on a variety of variables one of which may be the subjects participating in the experiment.

Flavell (1963) points out that for Piaget, mastery of the class inclusion relation and all its implication is the _sine qua non_ of concrete operational thought. Piaget further holds that class inclusion concept is attained at the age of 7-8 years. Contrary to this, Winer (1980) argues that there is sufficient evidence to indicate that class inclusion is a formal operational task. He bases his argument on the fact that many subjects who are advanced in age do fail class inclusion tasks and that 50% level of success is not attained until the age of eight years.

Winer's argument was not supported by the present study since class inclusion emerged as the easiest task of all. Furthermore, more than 50% (56% to be exact) of grade ones with a mean age of 6.5 had the concept of class inclusion. The performance was even better with grade twos whose mean age was 7.5 years; 70% of them had the concept of class inclusion. It could be demonstrated that class inclusion, in the present study was a prerequisite for successful performance in conservation and transitive inference in that 95.5% of those who failed in class inclusion also failed in conservation. Similarly 89.8% of those who failed class inclusion also failed transitive inference.

In summary, the primary objective of this study was achieved. A strong relationship exists between Das' model of information processing and Piaget's theory of cognitive development. For one to perform successfully on Piagetian concrete operational tasks, it is imperative that he be in adequate possession of simultaneous synthesis skills. It was also observed that older subjects performed better than younger subjects, thus confirming Piaget's claim regarding the role of maturation. On the other hand, this study has shown that in addition to maturation, one's strategy of information processing is just as crucial for successful performance.

IMPLICATIONS

The results of this study are of notable significance in a variety of ways. They are of notable significance in terms of Das' model, Piaget's theory of cognitive development, and those who have called for an alternative approach to the assessment of cognitive development.

In terms of Piaget's theory, the results indicate the theory's flexibility and susceptibility to other means of evaluating it other than the traditional approach. A new dimension is added in the sense that it can be assessed by means of a content-orientation approach or process-orientation approach. It thus satisfies the demands of both schools of thought, namely, those who want to assess cognitive development traditionally and those who are more interested in the process involved in cognitive development. Furthermore, this study has demonstrated that Piaget's claim regarding the role of maturation, and the concepts that constitute concrete operational thought is still valid. Consequently, Piaget's theory remains as one of the most reliable theories for developmental psychologists.

To those who have shown concern for an alternative approach, the results indicate clearly that Das' model of information processing may well be one of the possible alternatives they have been looking for. Das' model may also be considered of special interest for educators in view of its claim for susceptibility to remedial training. That means, where direct training of Piagetian tasks does not succeed, the researcher could resort to training by means of the process involved.

Such feasibility has been demonstrated by training subjects to process information successively to facilitate performance in tasks calling for such a strategy (Krywaniuk, 1974; Kaufman, 1978). A similar training could be undertaken for simultaneous synthesis. Regarding training, Das et al (1977) state:

> Training in either form of processing, if successful, should increase the level of school

> achievement. Furthermore, if one form of processing is less susceptible to instruction than the other, one could hope for an average level of achievement in students given special training in only one mode of processing. (p. 569)

In terms of Das' model, the results of this study are important in the sense that they indicate that Das' model is not an isolated one since it has been empirically shown both by this study and other studies (e.g. Jarman, 1980, Kirby, 1976) that it commands a significant relationship with other vital theories, such as Piaget's theory of cognitive development (Mwamwenda, 1980), Witkin's theory of psychological differentiation (Heemsbergen, 1979), Jensen's theory of memory and reasoning (Jarman, 1980) and a number of others.

But more than this, this study has shown that Das' model is capable of distinguising subject's performance on a given task given the strategy predominantly used in information processing, and that its postulates can be empirically supported. For example, the postulate that one strategy may be more suitable for solving certain problems given the nature of such a problem. Needless to say, this is the essence of any model worth its name. The results of this study are but a further demonstration that Das' model is a viable one worth further investigation.

Finally, the results of this study are relevantly significant because they extend our appreciation, knowledge and understanding of both Piaget's theory of cognitive development and Das' model of information processing. These two constructs are important because they have been of concern to many psychologists in the past, and probably will continue being of concern for many years to come.

For further exploration and research, it is recommended that a relationship between Piaget's stage of formal operation and Das' model be investigated. Secondly, it is suggested that a study be carried out to explore the feasibility of training subjects in simultaneous synthesis to determine whether such a training is likely to have an effect in their performance on Piagetian tasks either at the concrete operational level or formal operations. Since a relationship between spatial ability and Das' model has been established (Kirby, 1976), tasks of this nature could be used as training material. But more important than this, it will be necessary to establish how simultaneous synthesis as a process can be trained so that the experimenter will be able to detect those who are using the wrong strategy in processing information. This may be a lot of work, but it is not insurmountable.

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