THE DEVELOPMENTAL INTELLIGENCE OF BRAIN DAMAGED CHILDREN

A Thesis
Presented to
the Faculty of Graduate Studies and Research
University of Manitoba

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
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May 1970

ABSTRACT OF THESIS

The purpose of the present research was to study the maturity of reasoning of brain damaged children, and to investigate whether the thinking processes of these children follow the same sequence of stages as normal children.

A total of 34 tasks based on Jean Piaget's theory of developmental intelligence were selected on the basis of evidence that they formed a sequence of increasing difficulty level. The tasks were representative of the sensorimotor, preoperational, concrete operational, and formal operational stages. The brain damaged group consisted of 23 spastic cerebral palsy children aged four to fourteen years. Each brain damaged child was matched with respect to sex and chronological age to a normal child.

The results suggested that the brain damaged children follow the same sequence of developmental intelligence as the normal children, but that the thinking of the brain damaged children was less mature than that of the normal controls.

ACKNOWLEDGMENTS

The author wishes to express her appreciation to Dr. M.S. Aftanas for his help and encouragement.

Appreciation is also extended to the staff and teachers of the Society for Crippled Children and Adults, the Ellen Douglass School, and the Winnipeg School Division for their cooperation in this study.

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CHAPTER I

INTRODUCTION

1. STATEMENT OF THE PROBLEM

Research on brain damaged children centers around attempts to differentiate these children from normals. The experimenters assume that a brain lesion causes a qualitative difference in children. They find that certain perceptual handicaps accompany brain damage but rarely do they examine the thinking processes of these children. The purpose of the present study is to investigate whether the reasoning process of brain damaged children is similar to but perhaps progressing at a slower rate than that of non-brain damaged children.

Piaget's theory is one which emphasizes the thinking process rather than the content aspect of intelligence. In this study various tasks which are representative of four stages of development, will be given to a group of spastic cerebral palsied children of different ages. It is hypothesized that these children will give evidence of a developmental lag when compared to non-organic children but that their reasoning processes and responses will not differ from those of the normal child.

2. THE BRAIN DAMAGED CHILD

In recent years the fields of psychology and medicine have produced a tremendous amount of research on the brain damaged. Extensive reviews have appeared on the subject (Yates, 1954; Haynes & Sells, 1963; Herbert, 1964; Yates, 1966). The purpose of most of the research is to find reliable psychometric instruments which will aid in the differential diagnosis of brain damage. Contradictory results are common. Despite the fact that the field is rapidly gaining sophistication, researchers seem reluctant to correct past mistakes which are continually being pointed out to them. For example, subjects are diagnosed as brain damaged on the basis on a single criterion which may have been proven unreliable. Experimenters do not agree on the definition of brain damage, nor do they use the same model of brain functioning. One reason for the inconsistencies and confusion in the area is undoubtedly the innumerable problems inherent in the study of brain damage.

Many psychologists base their research on the assumption of a unitary concept of brain function. They regard a heterogeneous group of organics as a homogeneous whole. Work by Reitan (1966) on the Wechsler scales and other instruments leaves no doubt that classifying together organics of varying etiologies and lateralizations is a faulty procedure. Important differences between individuals are lost by this method. Other variables which should be controlled in experimental studies are the age at the time of damage and the amount of damage. However when all these factors are held reasonably constant, sample sizes are necessarily small.

As Birch (1964) points out, the fact and concept of brain damage must be differentiated. The concept of brain damage often refers to a behavioral pattern without explicit evidence of an anatomical lesion. Children are labelled brain damaged because of their hyperactivity or impulsiveness for example (Reitan, 1966). The fact of brain damage can refer to one of many varied neurological conditions including developmental abnormalities, complete destruction of an area of the brain from traumatic injury, damage from disease, or tumors of the brain (Reitan, 1966).

Physiologists have at least three main theoretical models of brain functioning: anatomical, field, and regional equipotentiality (Meyer, 1961).

In the anatomical theory, or associationism, an analogy is drawn comparing the workings of the brain with a complex telephone system having precise connections. Certain areas of the brain are associated with specific forms of behavior. Various maps have been constructed such as that proposed by Brodman over 50 years ago, which contains some 53 numbered subdivisions (Grossman, 1967). However, the theory has been severely criticized on the basis of experimental evidence. For example it has been found that 20 percent of the stimulation experiments on the so-called sensory cortex resulted in movement rather than sensation (Meyer, 1961). One must remember, though, that it is impossible to electrically stimulate one localized area without affecting other parts of the cortex.

Field Theory, on the other hand, is one of equipotentiality or mass action. Lashley (1929), a follower of this theory, hypothesized that the amount of damage to the brain rather than the location of the lesion, determined the degree of impairment. He suggested that cortical neurons are in continuous activity. Experimental evidence has not substantiated the Field Theory.

An intermediate position is taken by the Theory of Regional Equipotentiality or Functional Equivalence which argues for a limited form of localization. Hebb (1949), for example, hypothesizes how the development of a permanent memory trace takes place. In order for a certain perception to occur, particular cells in the central nervous system must be excited. A process of reverberation results in a transient memory, and after a certain period of time causes growth leading to a permanent change. A great deal of experimental evidence supports the theory of regional equipotentiality, although it will remain a theory until many underlying assumptions are proved. Because we do not yet have a working knowledge of brain functioning, our task in interpreting experimental results is all the more difficult.

A more useful approach to understanding brain damage in children has been proposed by the developmental theory of Ross (1959). This theory studies the increasingly mature manner in which the individual responds to his environment, and the results of cortical injury at various periods of life. The young infant reacts to stimuli in a global manner. Later he learns to differentiate stimuli. Differentiation is an inhibitory process in which the child responds to only the relevant stimuli. Still later he combines cues and can make a unified response. This process is called integration.

The child whose brain is injured around birth has not reached the required level of differentiation for integration to be developed. If the brain were injured during the critical period for the development of differentiation, then this disruption could manifest itself in an overresponsiveness to, or overgeneralization of stimuli. In the adult brain, in which integration has been established, an injury would result in still different forms of behavioral abnormality. In his theorizing, then, Ross stresses the importance of the developmental period in which the damage takes place.

As can be expected, medical information alone does not usually provide unequivocal evidence of brain damage. The physician uses several clues to arrive at a diagnosis of brain damage on the basis of historical data, neurological examinations, electroencephalograms, and developmental histories (Kennedy & Ramirez, 1964). A disease such as meningitis followed by a behavioral change would suggest positive evidence from historical data. In a survey of institutionalized cerebral palsied patients, Gauger (1950) noted that for 50 percent of the 105 cases the main cause of brain damage was trauma (prematurity, anoxia, prolonged labour, precipitate delivery, induced labour). In 21 percent of the cases infections such as encephalitis and meningitis caused the damage. Neurological indicators such as hyperreflexia, ataxia, and bilateral plantar reflexes are investigated. Hoedemaker and Murray (1952) found that a routine neurological examination detected 69 percent of brain damaged cases. Electroencephalograms (EEGs) are abnormal in 60 to 70 percent of brain damaged patients (Hoedemaker & Murray, 1952; Spreen & Benton, 1965), but are also positive in between 15 and 40 percent of normals (Kennedy & Ramirez, 1964). Although EEG measures alone are known to be fairly insensitive, many studies use them as the single criterion (Balthazar & Morrison, 1961; Pihl, 1968). X-ray contrast studies are often valuable, but contain a small amount of risk. Developmental signs which suggest brain damage in neonates and infants include absence of rooting and sucking behavior, vomiting early in life, very brief periods of sucking, and chewing difficulties. Since most of these medical indicators are not highly reliable when used alone, various psychological variables are also examined.

Rather than concentrating on the presence or absence of a brain lesion, psychologists can provide more valuable information by appraising the assets, liabilities, and unique behavioral patterns of the child (Robinson & Robinson, 1965).

Heinz Werner and Alfred Strauss pioneered in the American study of brain damage in children. Working at Wayne County Training School in the 1930's, they encouraged a group of young psychologists and teachers including Ruth Patterson, N. Kephart, and W. Cruickshank (Cruickshank, 1967). Strauss and Werner (1942) differentiated the endogenously mentally retarded from the exogenously retarded. They noted that brain damaged children are restless, easily distracted, and find it difficult to integrate stimuli into an organized whole. These characteristics were not found in the control subjects. Brain damaged children often react to irrelevant stimuli rather than focus selectively (Cruickshank, 1967). Although Benton (1962) cautions that not all brain damaged children can be diagnosed behaviorally, he notes certain characteristics including overactivity, awkwardness, postural rigidity, speech problems, visuo-motor difficulties, weakness in abstract reasoning, irritability, lack of affective ties, and aggressiveness.

Aside from these overinclusive descriptions of the brain damaged child, studies involving specific operational characteristics have been done. A perceptual problem is one such trait which is often called an indicator of neurological impairment. Although most children with severe perceptual difficulties are brain injured, not all brain damaged patients have these problems (Strauss & Lehtinem, 1947).

Marianne Frostig (Frostig, Lefever & Whittlesey, 1961) found five areas of perception which are often disturbed in neurologically handicapped children. These are eye-motor coordination, figure-ground perception, form constancy, position in space, and spatial relationships. Frostig's Developmental Test of Visual Perception was later further standardized on two thousand public school children aged three to eight years (Frostig, 1962). In the brain damaged population the average Perceptual Quotient was significantly lower than the average Intellectual Quotient. Furthermore, both the total score and the scatter of scores significantly differentiated brain damaged from normals.

Using the Stanford-Binet Intelligence Test (Terman & Merrill, 1937) several experimenters found that brain injured subjects were unable to reproduce the Diamond design. However Hoakley and Frazeur (1945) in testing 15 matched pairs of exogenous and endogenous mental defective children, found that nine of these pairs made equal scores on the Diamond design. The experimenters cautioned against using this subtest as a diagnostic tool.

Koppitz (1964) standardized the Bender Gestalt for children aged five to ten. She studied the testing behavior and protocols of 103 brain damaged children (Koppitz, 1962) only to find that while the total Bender score differentiated the organics from the normals at the .001 level of significance, all distortions occurred in both groups.

In a study on the Bender Gestalt, Smith and Martin (1967) found that it is possible to differentiate between neurotic and organic children both of whom do rotations on the Bender. They used a series of learning aids. Whenever a child rotated a figure, his paper was turned over and he was given the first of a succession of five learning cues. The series was continued until the design was drawn correctly. While most of the brain damaged children needed two or more cues, none of the neurotics did.

Other perception tests attempt to measure even more abilities than does the Bender Gestalt. The Visual Retention Test (Benton, 1955) involves visuomotor performance, learning, and immediate memory. These tests not only do not effectively differentiate between organics and normals, but they are also impure measures whose scores cannot be precisely interpreted.

Abercrombie (1964) stresses the importance of differentiating between perceptual and visuomotor disorders. Although organic children often demonstrate that they can perceive the diamond, they cannot draw it.

Bortner and Birch (1962) agree that a poor performance on a visuomotor task does not necessarily indicate inadequate perceptual ability. The Block Design subtest of the Wechsler Intelligence Scale for Children was originally intended to measure problems in visuomotor organization (Wechsler, 1944). Many psychologists interpret it in terms of the ability to perceive patterns. The brain damaged subject, they thought, did not do well on the test because of this inability. Bortner and Birch (1962) tested 28 cerebral palsied children. When a child failed to copy a design he was allowed to choose from 3 block models the correct one. Seventy-nine percent of the time the children could do this. They concluded that the Block Design subtest asks the subject to translate a perceptual organization into a reproduction. The experimenters hypothesized that there are two systems at work here representing two levels of development: a recognition-discrimination system and a more complex visuomotor one. This study and others like it emphasize the point that our knowledge in the area of perception is still inadequate. Usually experimenters feel that if they obtain more and more of the "same" types of measures of perception, their diagnosis will increase in sensitivity. However if their instruments were fewer but more precise, perhaps we would be closer to an understanding of the effects of brain damage.

The conclusions from most of the studies on brain damage are that cortical injury results in an organic change in the brain for which little if any improvement can be expected. However the various characteristics and difficulties brain damaged children experience could also be regarded as evidence of their immaturity. For example a child is not expected to be able to draw the diamond until about seven years of age on the Stanford-Binet (Terman & Merrill, 1937). Younger children have not attained the skills necessary for success on this subtest. As previously mentioned, Koppitz (1962) studying the Bender Gestalt on brain damaged and normal children found that all the distortions occurred in both groups. In this research, then, the visuomotor perception of the brain damaged subjects seemed to reflect quantitative rather than qualitative differences between the groups. Both the Smith and Martin (1967) and the Bortner and Birch (1962) studies suggested that while organic children may have delays in visuomotor ability, their problems in visual perception are not serious. Furthermore, some experimenters investigating concept formation have found concreteness of thinking to be characteristic of brain damaged children (e.g. Clawson, 1962; McMurray, 1954). Concreteness also distinguishes the thinking of normal young children according to the theory of Jean Piaget. Piaget (Piaget, 1950) hypothesizes that reasoning ability of children progresses through a predictable sequence of stages, each stage characterized by an increasingly mature type of thinking. Abstract reasoning belongs to one of the final stages of intellectual development. Young children are influenced by concrete stimuli and are not capable of this higher-order type of thinking. Therefore, by reinterpreting the results of the literature, there is ample evidence to support the idea that brain damaged children experience developmental delays rather than qualitative differences from their normal peers.

3. PIAGET'S THEORY OF INTELLIGENCE

Traditionally tests of intelligence are derived from empirical findings. Certain abilities are chosen to represent the various faculties of the mind. For example the child is asked questions of general information, social judgment, and vocabulary. His scores on the subtests are totalled and altogether constitute what is called a mental age.

Using the subject's chronological age, the mental age can be converted into an intelligence quotient. The intelligence quotient is a comparative rating which shows how the child performs in relation to other children of his age group. These tests are mainly concerned with the content aspect of intelligence, viz. what the child has learned in the past. Rarely are the tests designed to evaluate the child's thinking process. Exceptions to this generalization are the tests developed by Jean Piaget, a Swiss psychologist, who studies how children acquire various concepts. Although he has not gathered his material into a formal test battery, this is gradually being done by his followers. A test such as this would have the advantage of being based on a theory of intelligence.

On the basis of his studies of the thinking process Jean Piaget has formulated a developmental theory of intelligence. Piaget (1950) attempts to examine the organizational processes within an individual. Piaget views development as an inherent, unalterable process containing a series of distinct stages each of which is characterized by increasingly mature ways of solving problems. Each step is closely related to and necessary for the successive one. According to Piaget the sequence is invariant for all individuals.

Two processes, assimilation and accommodation, form the core of intelligence. Assimilation refers to the organization of experience - the adaptation of the environment to biological systems already in existence. The adaptation of the organism to the environment, or the change in behavior, is referred to as accommodation. The organism accommodates itself to external reality. Piaget says that every intellectual act involves an interpretation of the environment (mental assimilation). The situation is structured according to some existing system. Also a mental act involves an adaptation of existing systems to the reality conditions prevailing (mental accommodation). Piaget says that every mental act can be viewed as a balance or imbalance between assimilation and accommodation. Equilibrium occurs when incoming information is compatible with information already acquired.

There are three main periods in the ontogeny of intelligence (Flavell, 1963): the period of sensorimotor intelligence, the preparation for and organization of concrete operations, and the period of formal operations. The sensorimotor stage extends from birth to about two years of age. At first the infants' behaviors are only reflexes, and he is completely unable to differentiate between self and world. Later his actions become increasingly purposeful and organized. The young child knows what he wants but is not concerned with how he gets it. He begins to understand the permanency of the world and demonstrates goal directed behavior. He integrates information from the various senses and can understand this information as it pertains to the same objects.

The preoperational stage (age two to seven years) bridges the gap between the crude sensorimotor and the more stable concrete operational types of intelligence. The first third of this stage (two to four years of age) has not been adequately investigated but it is postulated that at this stage the child is beginning representational thought. He possesses the symbolic function (Flavell, 1963) which means he can evoke internally a signifier such as a word or image which represents an event not perceptually present. In the sensorimotor period events are linked individually rather than as a whole. Using the symbolic function, though, the older child is capable of uniting a series of events in order to comprehend the meaning. Actions are directed toward concrete goals in the earliest period, but the preoperational child is able to strive towards more abstract aims. There are several limitations to this stage, one of which is that the child's symbolic functions are ego-centric. For example if his speech cannot be understood by another person he won't attempt to modify it for the person. Furthermore the child centers his attention on one characteristic of an object ignoring other relevant aspects.

The five to seven year old child has matured in several ways. He can function in a test situation with an attempt to solve a given problem rather than simply to play with the materials involved. His thinking becomes more flexible. Instead of focusing on a single characteristic of an object, he slowly begins to see other traits as being important.

In the stage of concrete operations (usually from seven to about eleven years of age) cognitive systems become better organized and more solidly constructed. Communication is less egocentric and more social. For the first time cognitive operations are possible. Flavell (1963) defines an operation as being a symbolic act which is an important part of an organized network of related acts. For example, the child can add, subtract, multiply and form a single class from objects similar in one characteristic. The child's thought is not simply concerned with the actual but also with the potential (Inhelder & Piaget, 1958). The thinking of this stage is concrete rather than abstract. Although the child can think about the future he is primarily concerned with the here-and-now.

In the formal operations stage the older child has reached the final period of intellectual development. His thinking is increasingly abstract. When given a problem he thinks of all the possibilities which he tries or analyzes until he finds the correct solution. Now the child uses conjunction, disjunction, implication, and incompatibility in his reasoning. As Hunt (1961) says, the child shows a generalized orientation towards organizing data as he has more sophisticated logical systems to use to arrive at truths.

4. VALIDATION STUDIES

Research on the sequential aspect of Piaget's theory has generally followed one of three methods. Some studies have compared the acquisition ages of two or three types of conservation tasks such as mass, weight, and volume. Other experiments thoroughly analyzed the development of one concept by various scaling methods. Three recent studies (Goldschmid, 1967; Goldschmid & Benthler, 1968; Goldschmid, 1968) have been done testing young children on ten conservation tasks, thereby rating the difficulties of each. A review of the literature will outline agreements and disagreements with the developmental sequence Piaget proposes.

The sensorimotor period has not been investigated fully by researchers. Mary Woodward (1959) tested and confirmed Piaget's six sensorimotor stages when she examined the performance of 147 mental defectives. The children in the fifth stage discovered they could obtain an object out of reach if they pulled on an extension of it (in this case a string was attached). In the final stage in this period children could solve problems by foresight. If an object was out of reach, the child would use some other article, such as a stick, to obtain it.

Piaget and Inhelder (1963) found that in the preoperational stage - when the child is between 3 and 4 years of age - he can recognize common objects by tactile-kinaesthetic impressions. First the child is asked to identify visually some familiar objects such as a pencil, comb, spoon, and key. Then he puts his hands behind a screen and must identify each object (the original series of objects is shown to him throughout the task). Most children can do this at about three and one-half years, but when they are between $4\frac{1}{2}$ and $5\frac{1}{2}$, they can also identify more complex objects such as circles and ellipses, squares and rectangles (Piaget and Inhelder, 1963). Later at about $6\frac{1}{2}$ years of age, children can differentiate even more complex objects such as the star, Cross of Lorraine, swastika, semicircle, and semicircle with notches. Piaget and Inhelder write that this task involves two problems: the translation of tactile perceptions into visual ones, and the construction of a mental image using the data given from tactile exploration. This type of experiment demonstrates that the formation of mental images, immature as they might be, is possible at a very early age.

One indication of the child's having entered the concrete operations stage is his grasp of conservation concepts. Conservation refers to the principle that a particular aspect or dimension of an object will remain constant despite transformations in immediately irrelevant aspects. The various conservation concepts are grasped at different times throughout the concrete operational period. Controversy surrounds the question of the acquisition ages of these concepts.

According to Piaget (Piaget & Inhelder, 1947), children have discovered the conservation of mass by about seven to eight years of age. Elkind (1961a) found that 20 percent of children below age five can conserve mass while over 90 percent of those above age eleven can. Testing children between the ages of five and eleven, Keasey and Charles (1967) noted that 63 percent of them were able to conserve substance. Elkind (1961b) confirmed Piaget's findings that by age seven to eight 75 percent of children can conserve mass. Most experimenters agree that it is one of the easiest of the conservation tasks (Goldschmid, 1967;

Smedslund, 1961). The standard method is described by Flavell (1963). The child is shown two equal balls of plasticine. After he agrees they contain the same amount of clay, one of the balls is transformed into one of several shapes such as a sausage, hot dog, pancake, or several little balls of equal size. The child is asked if the transformed piece of plasticine contains the same amount of clay as it did before. It is generally agreed that conservation of mass occurs during the early years of the concrete operations stage.

There is controversy in the literature as to when children discover the conservation of length. Piaget's method (Flavell, 1963) consists of laying two identical sticks side by side, and asking the child if they are the same length. The end of one of the sticks is then moved a little to the right of the other stick, and the child is again asked if they are the same length. Using pencils, Elkind(1966) observed that 77 percent of the seven year olds he tested could conserve length. His young children (age four and five) were greatly confused when he tested the concept using the Muller-Lyer illusion, but by six and seven years of age this confusion disappears. Testing children with both the standard and the Muller-Lyer technique, Beilin and Franklin (1962) found that only 11 percent of their subjects in Grade 1 (mean age of six and one half) were conservers, but that 82 percent (mean age nine years) of the Grade 111 subjects were. Their results indicated that the conservation of length was easier than that of area. In one study Goldschmid (1967) testing 102 children, found that the conservation of length ranked third most difficult when compared to nine other types. However in a second study (Goldschmid, 1968), on similar subjects and with the same method, the conservation of length was the easiest of the ten tasks. Unfortunately

Goldschmid does not attempt to explain this in his later article. When he developed his conservation scales (Goldschmid & Bentler, 1968) the conservation of length was excluded because it was not homogeneous with the six tasks of his final scales. Instead he found that the area and length taks formed a homologous cluster which measured some other dimension of the conservation concept. Because of the confusion as to when this concept is grasped, the conservation of length should not be included in a Piagetian test battery composed of increasingly difficult tasks.

According to Piaget, the conservation of length and area are discovered simultaneously. As has been mentioned Beilin and Franklin (1962) found the conservation of length was achieved before that of area, and at about nine years of age most of his subjects could conserve area. The standard method (Piaget, Inhelder & Szeminska, 1960) for area consists of showing the child two pieces of green cardboard representing two fields of grass. A small cow is placed on each of the meadows and the child is asked if both cows have the same amount of grass to eat. After the child agrees, the experimenter places a barn on each of the meadows, and the child is again asked if both cows have the same amount of grass to eat. The experimenter tells the child that the farmer has decided to build some more barns, and he begins placing barns simultaneously on each field. In one case the barns are scattered throughout the meadow, in the second case they are lined up side by side which is perceptually distorting. The child is continually questioned as to whether each cow still has the same amount of grass to eat.

Goldschmid (1967, 1968) observed that the conservation of area was a little more difficult than conservation of weight, and somewhat easier than the conservation of volume. However although Goldschmid claimed to have used Flavell's (1963) method, he placed a maximum of six barns on each field. In his book Flavell cautioned that while young children will conserve up to about 10 barns, the child of six and a half to seven and a half shows conservation of area when as many as 15 or 20 pairs of barns are placed on the fields.

Goldschmid and Bentler's Scale C (1968) consisted of twelve items measuring the conservation of area and length. As was mentioned, this scale did not seem to measure the same aspect of conservation as the A and B Scales. However the Kuder-Richardson 20 coefficient for Scale C was .92 indicating that the scale is internally consistent.

Piaget (Piaget & Inhelder, 1947) noted that the child grasps the concept of weight conservation at about 9 or 10 years of age. Most researchers agree that the usual order of attainment is mass, weight, and volume (e.g. Elkind, 1961a). The usual method of measuring the concept is the same as that for conservation of substance, except that the child is asked to judge the relative weights of the two clay objects. In his investigations Goldschmid (1967, 1968) observed that area and weight conservations were of about equal difficulties. Items on the weight concept formed part of his ordinal homogeneous scales measuring a general conservation factor.

The conservation of volume is a complex concept and it is generally recognized that it does not appear until the period of formal operations. According to Piaget the child of 11 to 12 years has the necessary schemata to account for it. David Elkind (1961b) found, though, that only about 27% of Americans of this age had grasped this concept. Lovell and Ogilvie (1961) caution that the conservation of volume is very difficult to measure and it is unlikely that one test would be adequate. Piaget himself uses a variety of examining procedures (Piaget, Inhelder, & Szeminska, 1960). In one method the child is shown a standard either solid or made of blocks, which represents a house. He is asked to build another house on a different sized base with "just as much room" as the original. It appears that the conservation of number would also be involved in solving this problem. This is generally the method which Goldschmid used. Elkind (1961a, 1961b) changed the shapes of clay balls and asked about their relative volumes.

That the conservation of volume involves two different problems was investigated by Lunzer (1960). Internal volume refers to the space within an object's boundary surface. This internal kind of conservation appears when the child is about 7 years. Occupied volume pertains to the space taken up by the object in relation to an external medium. This concept is grasped at a much later stage of development. In one experiment the child was asked to predict how the level of water in a basin would change when an object of metal blocks was put upright, or secondly on its side, or with the blocks lining the bottom. About 58% of the 12 and 13 year olds could correctly solve problems on displacement volume. Testing children from about 6½ to 9½ years of age, Lovell and Ogilvie (1961) noted that young children think that the weight of the blocks is important in problems of displacement volume. Again this suggests that the conservation of weight must be attained before that of volume.

Goldschmid and Bentler (1968) found that the items on volume were not homogeneous enough to be included in his scales. The K-R 20 coefficient measuring reliability was low (.58).

As can be noted, one reason for confusion about the conservation of volume and other concepts has been the use of different methods. Piaget for one has favored a clinical method which involves an unknown degree of bias and subjectivity. Other researchers have attempted to standardize the experimental procedure for more objective and comparable results. While a clinical method is more enlightening for theoretical research purposes, a standardized technique should be adopted for experimental objectivity.

Other variables also affect conservation scores. Research indicates that conservation tasks are sensitive to differences in I.Q. (Goodnow & Bethon, 1966). Elkind (1961c) found that correlations with the WISC subtests were usually low but positive. Significant correlations existed between task scores and Picture Arrangement, Arithmetic, and Coding subtests. The Full Scale I.Q. correlated .43 which is significant at the .01 level of confidence. WISC vocabulary scores correlated in the .40 range with conservation scores whether behavior, explanation, or total scores were considered (Goldschmid, 1967). Correlations with I.Q. were around .30 in this study. Correspondingly Goldschmid and Bentler (1968) noted that school performance was an important variable.

At least two studies have demonstrated that a lack of formal schooling does not result in poorer performance on conservation tasks (Goodnow & Bethon, 1966; Mermelstein & Shulman, 1967). In the latter study schools in a Virginia county were closed for four years but the 60 Negro children tested were not behind their schooled peers.

Piaget and early investigators assumed there were no sex differences but recent research indicates that this variable cannot be ignored. While he observed no sex differences for the conservation of mass and weight, Elkind (1961b) found boys consistently better on volume concepts than girls, despite the fact that I.Q. scores favored the girls. The children in Goldschmid's study (1967) were about 7 to 9 years of age and the males did better in every conservation task. Bittner and Shinedling (1968) observed that for the children in Grade I, female subjects performed better than males, while in Grade III the opposite was the case. Testing children aged 4 to 7 years, Pratoomraj and Johnson (1966) found no difference due to sex, while Silverman and Schneider (1968) using a nonverbal method noticed trends for the earlier development of conservation in females. Therefore the effect of sex differences appears to be a confusing one. Perhaps one explanation could be obtained from Bittner and Shinedling's (1968) findings which pointed to examiner sex differences. For Grade I pupils, female examiners elicited the best performances, while males were the more effective examiners for Grade III students. These results could have interesting and important implications for the field of education as well as for future research on Piagetian concepts.

Longer life experience does not seem to contribute to higher conservation scores. Keasey and Charles (1967) matched 21 normals and 21 mentally retarded subjects for mental age. Although the chronological age of the retardates was on the average 11.4 years older, this increased life experience did not result in better performance. Goldschmid and Bentler (1968) tested 21 students from a school for emotionally disturbed children. They were about two years older than the eighty normals but their conservation scores were not superior. As can be seen from the recent literature, there are many variables which affect performance on conservation tasks.

In his research Piaget has been mainly concerned with the average, "normal" child. However he has advanced the theory that mental retardation is the result of a partial or complete stop at a certain developmental level (Piaget & Inhelder, 1947). A backward child proceeds through the sequence at a slower pace and perhaps never succeeds in reaching the level of formal operations. The theory has implications relevant to the study of subnormal children. Instead of focusing on what the retarded child can or cannot do, the psychologist would examine the child's type of thinking and maturity of reasoning.

5. THE DEVELOPMENTAL INTELLIGENCE OF BRAIN DAMAGED CHILDREN

Although there has been some research in which Piagetian tasks were administered to mentally retarded children, astonishingly little has been carried out on the brain damaged. Psychologists have been more interested in finding specific weaknesses in one ability or another, and haven't concerned themselves with examining the stage of development of the brain damaged child. The standard tests of intelligence are often not applicable to brain damaged children. In the Wechsler Intelligence Scale for Children (Wechsler, 1949), for example, subtests are continued until a certain number of items are failed. This is a discouraging process for the child who is desperately trying to overcome his problems and keep up with his peers. Anxiety is caused by the fact that the Performance tests are timed. Severe physical handicaps which often accompany brain damage will, by the nature of the tests, lower the child's score. However, the Piagetian tasks selected for the present study were more appropriate for brain damaged children than the more usual types of intelligence test for several reasons. All subtests are administered to each child, and the tests are not discontinued because of failure. The child is not really aware that he is failing, since he gives answers that are perfectly logical to him. None of the tests are timed, and fine motor coordination is not essential. Furthermore the materials involved (plasticine, blocks, toy cows for example) make the tests more similar to games than most types of tests of intelligence. The purpose of most of the IQ tests is to measure something which Wechsler calls intellectual ability. Piaget, though, does not concern himself with the content aspect of intelligence. Instead he looks at the thinking process - the maturity of thinking and reasoning that the child is using.

In the present study the thinking process of brain damaged children was examined. The stages of development and maturity of reasoning were compared to a group of normal controls matched for chronological age and sex. A series of 34 Piagetian tasks were selected from the literature on the basis of evidence that they formed a sequential group. Two problems were representative of sensorimotor intelligence; fourteen questions were asked from the preoperational stage; nine tasks were examples of concrete operational thought; nine questions from the formal operations stage were asked.

In order to have a relatively homogeneous group of subjects it was decided that spastic cerebral palsied children with whom the extent of motor damage is either quadriplegic or paraplegic be examined. Cerebral palsy refers to a variety of disorders actually, but they have in common a non-progressive lesion in the motor control centers and pathways of the brain. The brain damage may result from mechanical or chemical injury, infection, or congenital defects. According to Bartram (1964) the prevalence rate is about 100 to 600 cases per 100,000 population. These children have varying degrees of physical involvement, and about one half of them are considered to be mentally retarded. Speech and visual problems are found in about one half of cerebral palsied patients, while hearing difficulties are present in one quarter of them.

There are suggestions in the literature that brain damage at birth results in a maturational lag in the developmental process of intelligence. The present study is an attempt to investigate this theory. Therefore it is hypothesized that the developmental intelligence of children brain damaged at birth is lower than that of normal children, and that the performance of children brain damaged at birth is not qualitatively different from that of normal younger children.

CHAPTER II

METHOD

I. SUBJECTS

An examination of the literature indicates that certain variables must be considered in selecting brain damaged children for study. Often these children have speech, visual, or auditory problems. Children with severe defects in any of these areas were eliminated from the sample. The I.Q. of the child was only approximately controlled in that the exceptionally bright or dull child whose I.Q. was rated on the basis of the WISC or a group intelligence test, was excluded. The brain damaged group consisted of the total population of spastic paraplegic or quadriplegic cerebral palsied children who were attending the nursery of the Society for Crippled Children and Adults, and the Ellen Douglass School, a public school for handicapped children. The sample, after the eliminations stated above, consisted of 23 children. The medical diagnosis of 18 of these was spastic quadriplegia, while the remaining children were spastic paraplegics. The extent of physical impairment was not an eliminating factor because the subjects were not penalized for clumsy or slow performance on the tasks requiring manual exploration.

Each brain damaged subject was matched to a control child with respect to sex and chronological age. In the control group children with known or suspected brain damage were eliminated as were those with severe and uncorrected visual, auditory, or speech problems. The chronological ages of each pair did not differ by more than one month for the children under 13, and by six months for the older subjects. The total sample consisted of 46 children (26 males and 20 females) aged four to fourteen years.

2. PROCEDURE

Each child was examined individually by the experimenter. The subject and examiner were seated at a small table. Rapport was established before the testing commenced. All the tests for the school aged children were administered during one session. However the severely handicapped and the preschool cerebral palsied children were seen for two shorter sessions.

The Peabody Picture Vocabulary Test (Dunn, 1959) was administered to each child. Then the eight Piagetian subtests described below were given to each child.

Sensorimotor Intelligence

1. (a) A plastic flower was placed out of the child's reach. A cord, attached to the flower, was within the reach of the child. The child was then asked, "I want you to get the flower for me by moving only your arm. I don't want you to move the rest of your body." If the child didn't reach for the cord he was given a hint: "Can you think of any way to get that flower without moving your whole body?"

(b) The flower was placed out of reach again, but this time there was no cord attached. Instead a stick, 20" long, was nearby which could be used as a rake to obtain the flower. The child was told, "Get the flower for me again. Remember that I want you to move only your arm." The hint stated above was repeated if the child did not think of using the stick.

Preoperational Intelligence

2. (a) The child was shown an 8" by 11" piece of cardboard with four objects attached. This cardboard remained in the child's view. The objects were a pencil, comb, key, and spoon. The child was asked to name the objects. A box which contained two holes covered by a curtain was placed between the experimenter and the child. The child was told: "See, this box has two holes in it. I want you to put your hands in the holes. Now I'm going to hand you one of the objects. I want you to feel it really carefully, then tell me what it is." Objects identical to the ones on the demonstration card were given to the child who had to recognize them by tactile exploration alone. Each of the four objects was presented three times in a random order which was the same for all the subjects.

(b) The above procedure was repeated with five cardboard shapes: a circle, square, rectangle, ellipse, and triangle. The child was told he could name the shape or point to the shape on the demonstration card.

(c) The procedure was repeated with five more complex designs: a semi-circle, a semi-circle with notches, a cross, a star, and a swastika.

Concrete Operations

3. (a) Conservation of Mass Two balls of plasticine were placed in front of the child. The child was asked: "Do both balls have the same amount of clay?" If the child said they didn't, he was told to change them so that the two balls were equal in the amount of plasticine they contained.

The child was told "Now I'm going to make this one into a sausage. Do these clay pieces still have the same amount of clay, or does one piece have more or less clay than the other piece? How do you know?"

After answering the child was told, "Now I'm going to make this back into a ball again. Do both pieces have the same amount of clay?" The child had to agree before the experimenter continued. Then the child was told: "Now I'm going to make this one into a pancake. Now do these two pieces have the same amount of clay or does one piece have more or less clay than the other piece? Why?"

This general procedure was repeated and similar questions were asked when the ball was transformed into five little balls.

(b) Conservation of Weight Two clay balls were placed before the subject. The child was asked if they both weighed the same. If he didn't agree they weighed the same, he was told to change one in order to make both equal in weight. One ball was made into a hot dog, and the child was asked "Do these clay pieces still weigh the same or does one piece weigh more or less than the other piece? Why?"

The situation was repeated when the ball was changed to a ring, and then five little balls.

(c) Conservation of Area The child was shown two pieces of green cardboard. Plastic cows were placed on each piece of cardboard. As the examiner pointed to each piece of cardboard, the child was told: "These are a farmer's two fields of grass. This cow eats the grass in this field, and this cow eats the grass in this field. Do both cows have the same amount of grass to eat?" If the child didn't agree they had the same amount of grass, the experimenter told the child to measure the two fields to see if they were the same size. When the child agreed, he was told "Now the farmer decides to build some barns on the fields. He builds a barn on each field." While saying this the examiner placed a coloured wooden block which represented a barn, on each of the fields. The child was asked "Now does this cow have the same amount of grass to eat as this cow?" while pointing to each field. Again the child had to agree that both cows had the same amount of grass to eat. Then the child was told, "The farmer decides to build some more barns. Each time he builds one in this field, he builds one in this field." The experimenter placed four barns, one pair at a time, on each field. On one field the barns were arranged in a straight line along one side, while on the second field they were scattered throughout the field. The question was repeated, and the child was asked to justify his answer.

The same procedure was followed when nine and then fourteen barns were placed on each field.

Formal Operations

4. (a) Conservation of Internal Volume The child was shown two equal balls of plasticine. He was asked "Do the balls have the same amount of room inside them?" After the child agreed they did, he was told "Now I'm going to make this one into a pancake. Is there the same amount of room inside the pancake as inside the ball, or is there more or less room inside the pancake as in the ball? How do you know?"

The procedure was repeated as the ball was successively changed into a triangle, and a 6" stick.

(b) Conservation of External Volume After each transformation of the ball the child was told: "Let's see to what level the water will rise if I place the ball into the jar of water. How high will the water rise if I place the pancake into the jar? Will the water rise the same or more or less than when I put the ball into the jar? How do you know?"

Analysis of Responses

Sensorimotor Intelligence

1. (a) The child was credited five points for pulling the cord attached to the flower. Sometimes the child's motor handicap was so severe that he wasn't actually successful in obtaining the flower. However the child was given full credit if he was definitely attempting to reach for the cord. If the child needed the hint, he earned only two and a half points. If he still couldn't perform the task, he received a score of zero.

(b) The second task of sensorimotor intelligence was scored in a similar manner.

Therefore a total of 10 points was possible for the sensorimotor tasks.

Preoperational Intelligence

2. (a) Four objects were presented to the child three times each making a total of 12 responses. The subject's raw score was divided by twelve, then multiplied by 10 to make a total possible score of ten points.

$$\frac{\text{Raw Score}}{12} \times 10$$

(b) In this subtest five shapes were presented to the child three times each. The total number of responses was fifteen. The subject's raw score was divided by fifteen and multiplied by 10 to make a total possible score of 10 points.

$$\frac{\text{Raw Score}}{15} \times 10$$

(c) Again there were five shapes each presented three times to make fifteen responses. The subject's raw score was divided by 15 and multiplied by 10, to make a total possible score of 10.

$$\frac{\text{Raw Score}}{15} \times 10$$

The three subtests on Preoperational Intelligence contributed 30 points to the total Piagetian score.

Concrete Operations

3. (a) Conservation of Mass When the concept of the conservation of mass was examined, the ball was transformed into three different shapes. After each transformation the child was asked if the two pieces still contained the same amount of clay. He was given one point for each transformation if he correctly answered the question irregardless of his reason. If the child gave the correct reason for his conservation response, he was credited with two additional points. Therefore three points could be earned for each of the three transformations making a total of nine points. The child's raw score was divided by nine, and multiplied by ten to make a total possible score of 10 points.

$$\frac{\text{Raw Score}}{9} \times 10$$

(b) Conservation of Weight The same scoring procedure which was used for the conservation of mass was followed for the conservation of weight subtest. Again after each transformation the child was credited one point for stating the correct response and two points for the correct reason. Therefore nine points were possible. The subject's raw score was divided by nine and multiplied by ten to make a total possible score of ten points.

$$\frac{\text{Raw Score}}{9} \times 10$$

(c) Conservation of Area The conservation of area subtest was scored in a similar manner to the other conservation subtests. After four barns were placed on each field, the child received one point if he said both cows had the same amount of grass to eat. Again he earned two additional points for stating the proper reason. This procedure was followed for the other two transformations in which nine and then fourteen barns were added to the fields. The total number of points was nine. The subject's raw score was divided by nine and multiplied by ten to give a total possible score of 10 points.

$$\frac{\text{Raw Score}}{9} \times 10$$

Therefore the total possible score for the Concrete Operations tasks was 30 points.

Formal Operations

4. (a) Conservation of Internal Volume In examining the conservation of volume three transformations were administered to each child. The same procedure was followed in each case. The child was credited one point for stating the ball and the transformed shape had the same internal volume. An additional point was given when the child knew the correct reason for the response.

(b) Conservation of External Volume The conservation of external volume was tested when the child compared the water level of the transformed object in the jar to the water level of the ball in the jar.

He earned one point for giving the desired conservation response, and a second point for stating the proper reason.

(a) and (b) Therefore for each of the three transformations, four points were possible. The total number of points for the conservation of volume was twelve. The child's raw score was divided by twelve, and multiplied by 10 to make a total possible score of 10.

$$\frac{\text{Raw Score}}{12} \times 10$$

Therefore it was possible to earn a total of 10 points for the Formal Operations tests.

Analysis of Results

To test the hypothesis that the developmental intelligence of brain damaged children is lower than that of normals, the Piagetian scores were analyzed by the t-test for matched samples.

To demonstrate the similarity in progression of developmental intelligence between the brain damaged and normal children a Spearman rank-order correlation was calculated. A second Spearman correlation was computed between chronological age and Piagetian score for the brain damaged children to investigate the relationship between these two variables. The numbers of children from both groups in each of the Piagetian stages were analyzed by a Chi-square to see if the groups were significantly different in this respect.

CHAPTER III

RESULTS

Figures 1 and 2 outline the Piagetian score distribution for the brain damaged and normal children plotted as a function of chronological age. The Spearman rank-order correlation coefficient between chronological age and Piagetian score was .77 for the brain damaged children and .70 for the normal children. Both these coefficients were found to be significant at the .01 level indicating the high degree of relationship between age and maturity of reasoning for both the brain damaged and normal groups. To demonstrate the similarity in progression of developmental intelligence between the brain damaged and normal children, a Spearman rank-order correlation was applied to the Piagetian scores of the matched pairs. The correlation coefficient was .68 which was found significant at the .01 level. This correlation suggested a fairly high degree of consistency between the scores for the two groups. The numbers of normal and cerebral palsied children in each of the Piagetian stages are presented in Table 1. A Chi-square was computed on the frequency of children in the preoperational, concrete operational, and formal operational stages, and the results were found to be not significant.

TABLE 1

Numbers of Normal and Brain Damaged Children in each of the Piagetian Stages

	Preoperational	Concrete Operational	Formal Operational
Brain Damaged	16	6	1
Normal	11	7	5

Chi-square = 4.34; $p > .05$

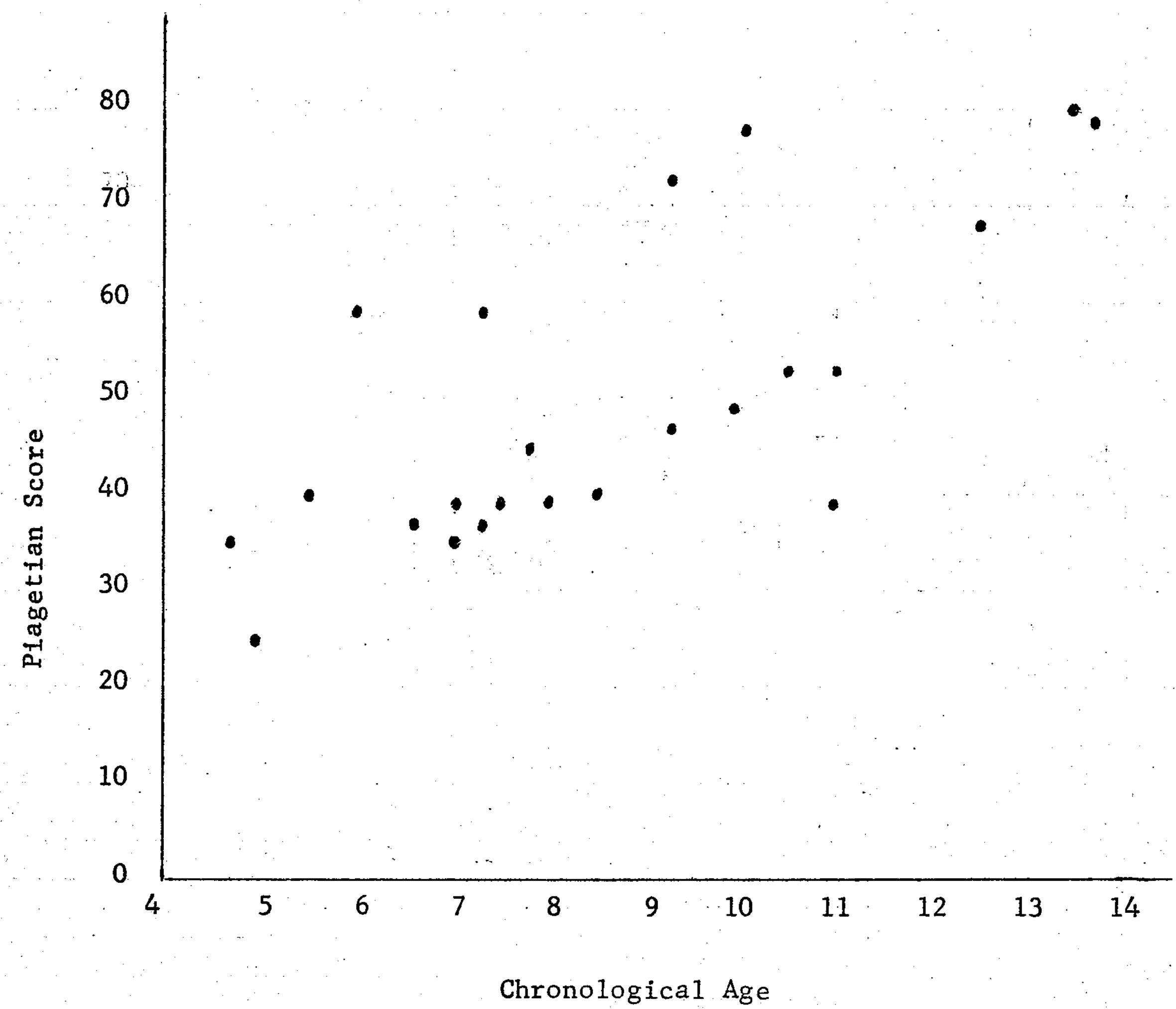

FIGURE 1 Relationship Between Piagetian Score and Chronological Age for Normal Children

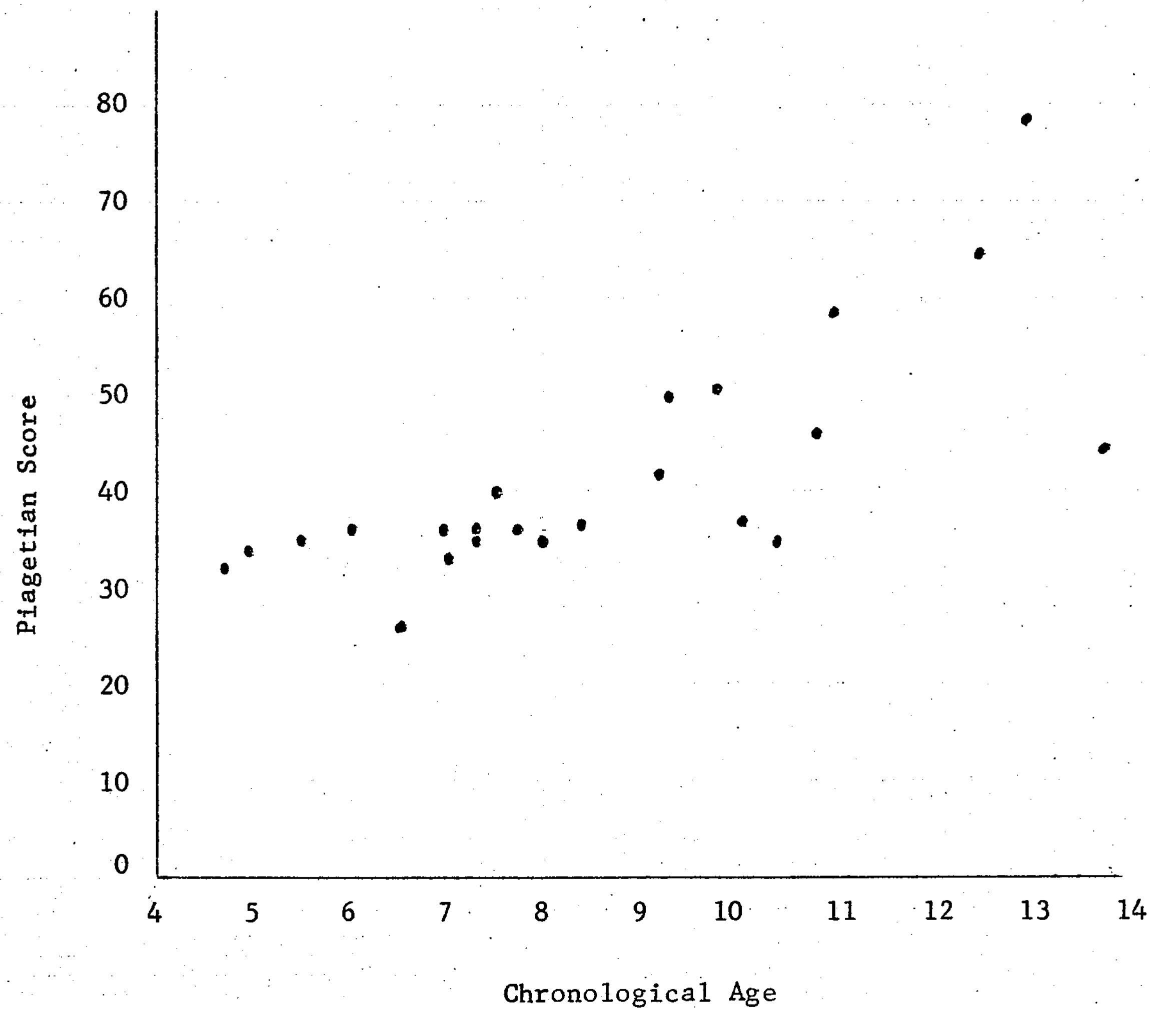

FIGURE 2 Relationship Between Piagetian Score and Chronological Age for Brain Damaged Children

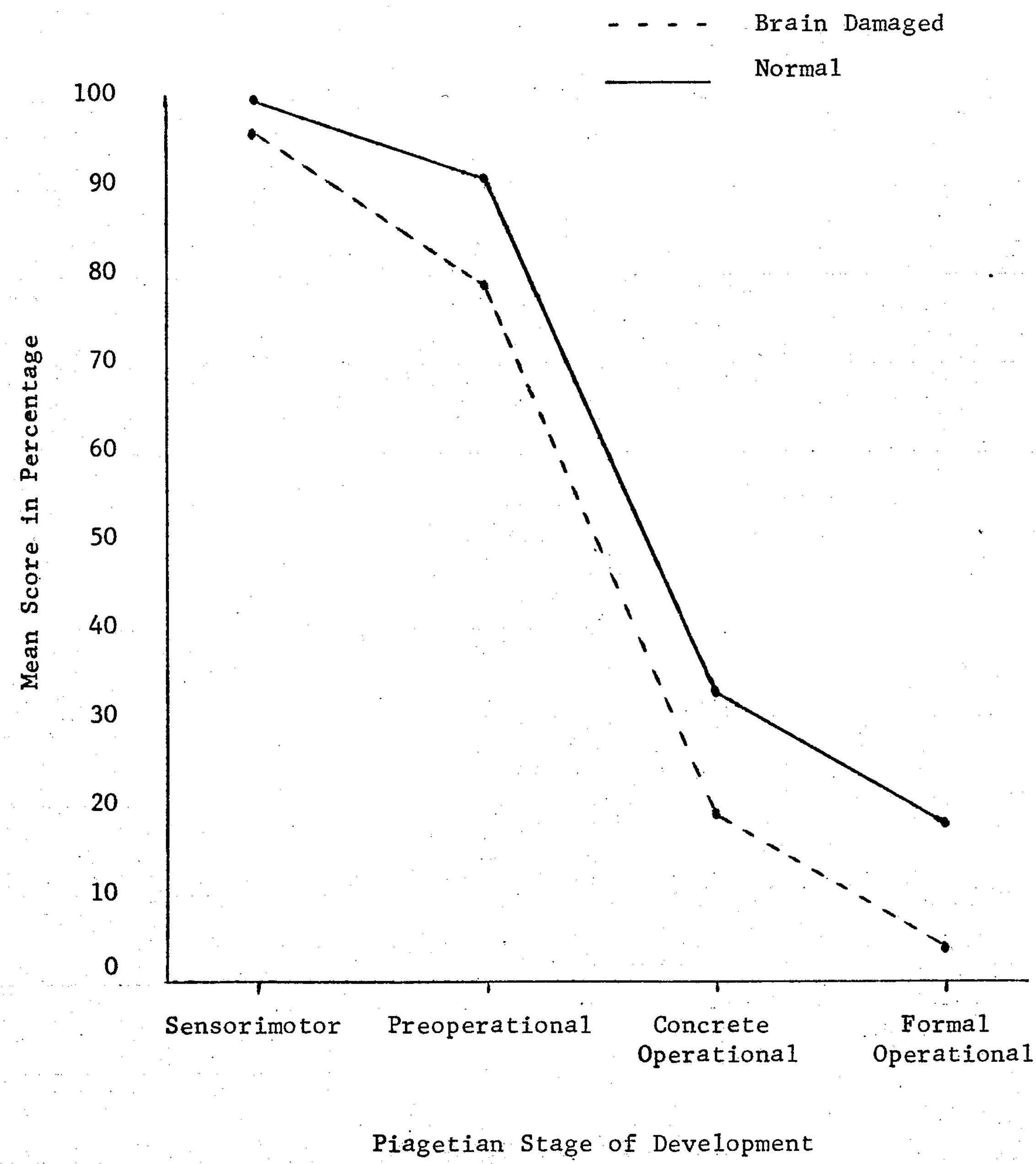

FIGURE 3 Mean Score of Tasks from each Piagetian Stage in Percentage

As is indicated in Figure 3, it is evident that the brain damaged children as well as the normals found the sensorimotor tasks to be the easiest, followed by the preoperational, concrete operational, and then formal operational tasks. This figure presents the average scores in percentages of the tests from each Piagetian stage for the brain damaged and normal children.

Table 2 outlines the numbers of brain damaged and control children who scored above and below 90 percent on the sensorimotor tasks. A score of 90 percent was chosen as the cut-off score because it was just below average for the brain damaged children and appeared to differentiate the groups. A Chi-square test applied to the frequency of children scoring above and below 90 percent indicated that the difference between the two groups was significant at the .001 level. However the indication of a significant relationship between sensorimotor skills and age for the cerebral palsied children was suggested by the Spearman rank-order correlation computed between the total score on the subtests involving sensorimotor ability, and the chronological age of each child. The correlation coefficient was .541, which was found to be significant at the .01 level.

TABLE 2

Frequency of Brain Damaged and Normal Children Scoring Above and Below 90% on the Sensorimotor Tasks

	Below 90%	Above 90%
Brain Damaged	19	4
Normal	5	18

Chi-square = 17.94; $p < .001$

The brain damaged children were hypothesized to be lagging behind the normal controls in terms of developmental intelligence. To test this hypothesis a t-test for matched groups was applied to the total Piagetian scores. The resultant t value of 3.588, with 22 degrees of freedom was found to be significant at the .01 level. The developmental lag was demonstrated when the mean age of the children in each of the Piagetian stages was computed. In the concrete operations period the average age of the brain damaged children was 11 years 2 months as compared with an average age of 8 years 10 months for the normal subjects. These data are presented in Table 3.

TABLE 3

Mean Age of Children within each Piagetian Stage

	Sensorimotor and Preoperational	Concrete Operational	Formal Operational
Brain Damaged	7-4	11-2	13-0
Normal	7-2	8-10	12-4

The results indicated that the brain damaged children were behind the control children in reaching the stage of concrete operations. In the normal group 50 percent of the children aged 7 years 6 months to 9 years 6 months were within the concrete operations stage, which suggests that the age of entering the stage is probably about 8 years 6 months. About one half of the brain damaged children aged 9 to 11 years were within this stage of developmental intelligence. Therefore the brain damaged children appeared to enter the concrete operations stage at about 10 years of age, a year and a half behind their normal peers.

Table 4 outlines the non-conservation responses for the two groups. The data indicate that in both groups children were led to wrong conclusions mainly because of perceptual aspects of the stimulus situation. Perceptual errors occur when the child is guided more by his perceptions than by logical deduction. For example a "perceptual" answer would be the following: "The ball weighs more than the ring because it's bigger." Sixty-eight percent of the non-conservation responses of the brain damaged children were "perceptual", while 82 percent of the time the normal children used this type of explanation. No reason was given for 23 percent of the brain damaged and 18 percent of the normal children's answers. There were more nonsensical responses in the cerebral palsy group than the normal group. A Chi-square test was applied to the frequency of perceptual, nonsensical, and "no response" answers for both groups. The Chi-square was found to be significant at the .001 level.

TABLE 4

Non-conservation Responses of Brain Damaged and Normal Children in Frequencies and Percentages

	Cerebral Palsied	Normal
Perceptual	164 (68.3%)	174 (81.7%)
No Response	56 (23.3%)	38 (17.7%)
Nonsensical	20 (8.3%)	1 (0.5%)

Chi-square = 19.48; $p < .001$

The Peabody Picture Vocabulary Test has been considered a valuable tool for assessing the intelligence of cerebral palsied children. Although the brain damaged and normal children differed significantly in terms of developmental intelligence, their scores on the Peabody were very similar. The Wilcoxon matched-pairs signed-ranks test yielded a T of 109 which demonstrated that the vocabulary scores of the two groups were not significantly different.

The results of the study indicated that the conservation tests represented a sequence of increasingly difficult tasks. Table 5 outlines the mean scores expressed in percentages of the four conservation subtests for the brain damaged children, the normal children, and the total sample. The level of difficulty as measured by the mean scores in percentages of each of the tests was similar for the normal and brain damaged children. For both groups the conservation of mass was the least difficult, followed by the conservation of weight, area, and volume.

TABLE 5

Mean Scores of Conservation Subtests in Percentages

	Brain Damaged	Normal	Total Sample
Mass	25.3%	47.8%	37.7%
Weight	20.3%	31.8%	26.1%
Area	12.5%	19.3%	15.9%
Volume	4.4%	18.1%	11.2%

CHAPTER IV

DISCUSSION

According to Piaget the progression of developmental intelligence is similar for all children. The concepts acquired during an earlier stage are necessary antecedents for the more complex and mature thinking characteristic of the next stage. Investigations done in various countries have tended to confirm Piaget's theory which was formulated mainly from his observations on his own children in Switzerland. In general researchers have found that while the age of concept acquisition may vary across cultures, the sequence of progressions is universal. Research in Canada, for example, has included a study on the developmental intelligence of Canadian Indian and white children (Margolis, 1968). Goodnow (1962), after administering Piagetian tasks to Chinese and European children did not observe any significant cultural differences. Studies in the United States such as those by Elkind (1966) concluded that the progression of developmental intelligence is similar to that proposed by Piaget although minor deviations in acquisition age were frequently noted.

While most of the research has explored the developmental sequence for the normal child, the exceptional child has rarely been studied. In the present study a series of Piagetian tasks were administered to children brain damaged at birth. The reasoning ability of the brain damaged children placed them in all the stages of development beyond the sensorimotor period. Therefore, each child was within one of the preoperational, concrete operational, or formal operational stages. The distribution of scores in relation to chronological age was similar for the brain damaged and normal children. The Spearman rank-order correlation between the matched pairs of cerebral palsied and normal children yielded a significant coefficient. There was a high positive relationship between the chronological age of the cerebral palsied child and the Piagetian score. Therefore the universality of Piaget's developmental theory is further substantiated by the finding that brain damaged children appear to follow the same sequence as normal children.

In view of the universality in the stages of intellectual development, it is suggested that the application of Piaget's theory to brain damaged children can contribute valuable information about their reasoning processes and maturity of thinking. Development of the Piagetian tests could lead to a measure of cognition more valid than the standard intelligence tests administered to brain damaged children. The Piagetian tasks have several practical advantages for this group: they are untimed; they are structured yet seem to be like little games; they involve materials the child can touch and manipulate; they are suitable over a fairly large age range; they examine the child's response as well as his reason for that response; they do not involve perceptual motor speed. Furthermore interpretation of Piagetian tests is more meaningful for brain damaged children than the usual type of tests. The Piagetian tests investigate the actual thinking process, rather than compare how the child performs in one area or another with how others of his age perform.

The hypothesis that the Piagetian tests formed a sequence of increasing difficulty level was confirmed by the results of this study. As predicted the sensorimotor subtests were the least difficult, followed by the preoperational, concrete operational, and formal operational tests.

Difficulty level here is defined in terms of the mean score of the tests from each Piagetian stage for both groups of children. According to many experimenters including Smedslund (1961) and Elkind (1961a) the conservation of mass is one of the easiest conservation tasks. The results of the present study essentially substantiated this finding. Goldschmid (1967, 1968) reported that the conservation of weight was easier than area conservation, which in turn was less difficult than conservation of volume. The order of difficulty of the tests in this study duplicated Goldschmid's sequence for both brain damaged and normal children.

The results also indicated that the cerebral palsied children lagged behind the non-brain damaged controls in the area of developmental intelligence. In 17 of the 23 matched pairs the Piagetian score of the control child was higher than that of the brain damaged child. The immaturity of the thinking of the brain damaged children was further illustrated by the finding that only 30 percent of those children were well within the concrete operations or formal operations stage. However 52 percent of the control children had reached these stages of intellectual development. Correspondingly, five of the controls were what Piaget calls "formal thinkers" while only one of the cerebral palsied subjects could be placed in that category. The results strongly suggest that cerebral insult of the young brain retards the normal progression of intellectual development.

Various disturbances in perceptual areas have been noted in brain damaged children (Strauss & Lehtinem, 1947; Frostig, 1962). By definition the cerebral palsied have a motor handicap. In this study the brain damaged subjects did not do as well as the normal controls on the sensorimotor tests. However the finding that ability in the sensorimotor tasks was significantly related to age indicates that in general the older brain damaged children were more skilled in this ability than the younger. The relatively poor performance of the brain damaged children on the motor tests appears to be another indication of a maturational lag, rather than a fixed disability which cannot be improved.

In the present study the cerebral palsy group lagged approximately one and a half years behind the normal controls in entering the concrete operations stage, although more subjects would have to be studied to confirm this finding. In the brain damaged group none of the children nine years or below were within the concrete operations stage, whereas about one quarter of the normal children of those ages were. Of the children over nine years, 90 percent of the normals, and about 70 percent of the brain damaged were thinking at a concrete operational or formal operational level. The mean age of the brain damaged children in the concrete operational stage was 11 years 2 months, with a range from 9 years 3 months to 13 years 10 months of age. However the mean age of the normal children within the concrete operations stage was 8 years 10 months, with a range from 6 to 11 years of age.

Although the cerebral palsied children appeared to be progressing through the stages of development at a slower pace, their thinking did not seem to be qualitatively different from that of the normal children. That is it was similar to normal, usually younger children. Most of the non-conservation responses in both groups were classified as "perceptual" answers because the child's reasoning was dominated by one perceptual aspect of the situation. Examples of "perceptual" responses are the following :"The sausage has more clay than the ball because it's longer", or "The pancake has less room inside it because it's flatter than the ball." The analysis of the non-conservation responses indicated that eight percent of the reasons the brain damaged children gave were nonsensical, such as, "The sausage is bigger than the ball because my mom told me". With the normal group of children less than one percent of the non-conservation responses were this type.

An explanation for the finding that the brain damaged children used more nonsensical reasons than the normal children could be gained from Piaget's description of the thought processes of preoperational children. According to Piaget the young child has to find a reason for everything. When incoming information is incompatible with information already present, the child will give a reason, any reason, which will serve to maintain balance and achieve equilibrium. The child tends to causally relate two events which occur contiguously in perception. The thought processes could progress as follows: as the experimenter explains he is making the ball into a sausage, the child is reminded of his mother who cooks sausages and who tells him things. Therefore the two perceptions, mother and the ball's being transformed into a sausage, occur together in time. The child relates them casually saying the reason he knows is that his mom told him. Although the theory hasn't been tested, it is suggested that this nonsensical type of reply exemplifies even less mature thinking processes than "perceptual" or "I don't know" replies. Unfortunately because very few nonsensical reasons were given in the normal group, the theory could not be tested in the present study.

The results suggested that the cerebral palsy children are at a distinct disadvantage during the early school years when compared to normal children. Because the cerebral palsy children were about a year and a half behind the normal child in entering the concrete operations stage they would be limited by the type of thinking characteristic of the preoperational stage of intelligence. The main property of preoperational thought is the child's tendency to concentrate or "center" on a striking aspect of an object, ignoring other relevant aspects (Baldwin, 1968). For example after the young child notices that the sausage is longer than the ball, he immediately concludes that it has more clay. He doesn't take into account the fact that the sausage is longer but also narrower than the ball. The preoperational child will jump to conclusions on the basis of insufficient evidence. His thinking proceeds from particular to particular without uniting events into a logical whole. Instead the child tends to integrate events which occur together in time in a global manner as was described above. Since the preoperational child is egocentric, he cannot imagine viewpoints which are different from his own. In speech, words are connected in an associative manner, rather than by causal expressions such as "since" or "because". Therefore there are many limitations to preoperational thought.

Throughout the literature researchers have portrayed organic children by various behavioral descriptions. Investigators have emphasized the distractibility of brain damaged children and the fact that they cannot focus selectively on stimuli (Cruickshank, 1967). These are also characteristics of young normal children. Ilg and Ames (1955) describe the general restlessness typical of the six year old for example.

> "He cannot adapt. It is others who must do the adapting. ...This is an expansive age and the 6-year-old is ready for almost anything. ...It is most difficult for him to choose between two alternatives because he wants both. ...He is as rigid and as unadaptable in his relations with others as he was earlier at 2 and a half."
>
> (Ilg & Ames, 1955, p. 46).

Since the present study suggests that the thinking of brain damaged children is less mature than that of normal children, the results could be generalized to behavioral aspects as well. Because the preoperational child tends to focus on one aspect of a situation at a time, arrives at erroneous conclusions, and fails to integrate events into sequences or wholes, his distractibility is perhaps understandable. Similarly a frequently reported characteristic of brain damaged children is the concreteness of their thinking (McMurray, 1954; Clawson, 1962). However according to Inhelder (Inhelder & Piaget, 1958) the ability to use abstract reasoning follows a developmental sequence. In the concrete operations stage the child is mainly concerned with the actual rather than the potential. His thinking is concrete during this stage and it isn't until the period of formal operations that the child has the resources to fully engage in abstract thinking. Although several brain damaged children in the present study were approaching the type of thinking distinguishing the formal operations stage, only one child was actually within this stage of cognitive development. Therefore in Piagetian theory concreteness of thought can be explained in terms of a delay in intellectual maturation.

Ross(1959) believes that the developmental period during which injury takes place, that is whether the victim is an infant, a growing child, or an adult is significant in determining the behavioral ramifications of that injury. In the present study all the brain damaged children were injured at birth. The thinking processes of these children followed the normal progression of intelligence. Future research generated by this study could involve the investigation of developmental intelligence of brain damaged persons injured during later childhood or adulthood.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of the research was to study the thinking processes of brain damaged children by administering tasks from Piaget's theory of developmental intelligence. In order to have a fairly homogeneous group of subjects the brain damaged sample consisted of 23 spastic cerebral palsy children. The brain damaged children ranged in age from 4 to 14 years. Their performance was compared to that of a normal group of children matched individually to the cerebral palsied children with respect to chronological age and sex.

A series of 34 tasks were selected from the literature on the basis of evidence that they formed a developmental sequence. There were two problems representative of sensorimotor intelligence; fourteen questions were asked from the preoperational stage; nine tasks were examples of concrete operational thought; nine problems from the formal operations stage were asked.

The results presented further evidence of the universality of the sequential aspect of Piaget's theory of developmental intelligence because the brain damaged children appeared to follow the same sequence of stages as normal children. There was a strong positive relationship between chronological age and total Piagetian score for both the brain damaged and normal children. The cerebral palsied sample seemed to experience a developmental lag when compared to the normal controls.

Although the cerebral palsied children were found to be thinking within each of the stages of intellectual development, only one of these children had reached the final stage, that of formal operational thought. The mean age of entrance into the concrete operational stage was approximately one and a half years earlier for the normal children than the cerebral palsied children. Some implications of this developmental lag were discussed, as were several reasons outlining the appropriateness of Piagetian tests for brain damaged children.

Further research generated from this study could include investigations on the developmental intelligence of brain damaged victims injured in later childhood or adulthood. It would be important to explore how brain damage later in life affects the developmental progression.

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APPENDIX A

Piagetian Test Scores for each subject

1. Brain Damaged Subjects

C.A.	Sensorimotor		Preoperational		Concrete Operations			Formal Operations
4-8	10.0	9.1	3.3	6.7	0	0	3.3	0
4-11	7.5	10.0	8.0	8.6	0	0	0	0
5-6	10.0	10.0	5.3	6.7	0	0	3.3	0
6-0	7.5	10.0	9.3	9.3	0	0	0	0
6-7	7.5	7.5	4.7	6.0	0	0	0	0
6-11	10.0	10.0	6.7	9.3	0	0	0	0
7-0	7.5	8.3	6.0	8.7	0	0	2.2	0
7-4	10.0	10.0	9.3	6.0	0	0	0	0
7-4	10.0	10.0	8.7	7.4	0	0	0	0
7-6	10.0	10.0	10.0	10.0	0	0	0	0
7- 8	10.0	10.0	8.0	8.0	0	0	0	0
8-0	10.0	10.0	6.7	8.7	0	0	0	0
8-5	10.0	10.0	8.0	8.7	0	0	0	0
9-2	10.0	10.0	8.7	9.3	3.3	0	0	0
9-3	10.0	10.0	8.0	8.7	10.0	3.3	0	0
9-10	10.0	10.0	8.7	9.3	10.0	3.3	0	0
10-1	10.0	10.0	8.0	8.7	0	0	0	0
10-5	10.0	10.0	4.7	9.3	0	0	0	0
10-10	10.0	10.0	8.0	8.0	0	10.0	0	0
11-0	10.0	10.0	9.3	9.3	10.0	10.0	0	0
12-6	10.0	10.0	6.0	9.3	10.0	10.0	10.0	0
13-0	10.0	10.0	8.7	10.0	10.0	10.0	10.0	10.0
13-10	10.0	10.0	5.3	9.3	10.0	0	0	0

2. Normal Subjects

4-8	10.0	10.0	6.7	7.3	0	0	1.1	0
4-11	10.0	10.0	3.3	1.3	0	0	0	0
5-6	10.0	10.0	10.0	10.0	0	0	0	0
6-0	10.0	10.0	9.3	10.0	10.0	10.0	0	0
6-7	10.0	10.0	7.3	10.0	0	0	0	0
7-0	10.0	10.0	8.7	8.0	0	0	0	0
7-0	10.0	10.0	9.3	9.3	10.0	10.0	0	0
7-4	10.0	10.0	7.3	9.3	0	0	0	0
7-4	10.0	10.0	8.7	10.0	10.0	10.0	10.0	0
7-6	10.0	10.0	9.3	10.0	0	0	0	0
7-9	10.0	10.0	9.3	9.3	3.3	3.3	0	0
8-0	10.0	10.0	10.0	9.3	0	0	0	0
8-5	10.0	10.0	10.0	10.0	0	0	0	0
9-3	10.0	10.0	10.0	10.0	6.7	0	0	0
9-4	10.0	10.0	10.0	10.0	10.0	10.0	3.3	10.0

APPENDIX A (Continued)

C. A.	Sensorimotor		Preoperational		Concrete Operations			Formal Operations
9-11	10.0	10.0	8.7	10.0	10.0	0	0	0
10-2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	7.5
10-6	10.0	10.0	10.0	10.0	10.0	3.3	0	0
10-11	10.0	10.0	8.7	10.0	0	0	0	0
11-0	10.0	10.0	10.0	10.0	10.0	0	3.3	0
12-6	10.0	10.0	10.0	10.0	10.0	6.7	6.7	5.0
13-6	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
13-8	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.1