PERFORMANCE OF NORMALS AND RETARDATES ON PIAGET'S CONSERVATION TASKS

By

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Piaget's theory of cognitive development has been the source of a great deal of research, particularly in the area of conservation attainment. A review of the literature revealed that few of the previous studies in this area involved mentally retarded subjects. Because of the sparsity of research aimed at examining retardates in relation to Piaget's findings with normals, the present study was undertaken.

In this study, 30 mental retardates, divided equally into two mental age groups (7 to 9 and 10 to 11 years), were matched with an equal number of normals for mental age. Both IQ groups were presented three types of conservation tasks, namely, mass, weight and volume, using the initial technique employed by Piaget, i.e., the transformation of one of two identical clay balls. However, the present method differed in that the subjects were required to select one of the three possible judgments presented to them after a trans-

formation, and then explain the reason for their choice. Three different transformations were performed for each of the types of conservation, so that a total of nine trials was administered to each subject.

The results, in addition to supporting previous studies concerning the significance of age and type of conservation as variables affecting conservation performance, confirmed the major hypothesis of this study. The normals attained significantly higher conservation scores than the retardates. An unexpected finding was the extent of this disparity between the normal and retardate performances. This was due to both the poor performance of the retardates and the somewhat advanced performance of the normals. As a result, three hypotheses on more specific aspects of the subjects' performances were not verified.

The findings of the present study were related to Inhelder's theory that attempts to account for the delayed development of mental operations in retardates. She maintains that the equilibrium attained by retardates in their cognitive development is a pseudo-equilibrium, i.e., it contains some intuitive elements of earlier mental stages.

Also discussed was the relevance of the present findings to the area of mental retardation. Piaget and Inhelder have long maintained that present diagnostic methods are inadequate because they do not examine actual thought processes but only measure the efficiency of intelligence in relation to certain norms. The results of this study support the position that these two approaches do not yield comparable results as far as evaluating the mental capacities of an individual. The possible implication of assessment based on an evaluation of mental operations for educating and training retardates was also noted.

INTRODUCTION

When the area of cognitive development comes under discussion, one name inevitably comes to mind, that of Jean Piaget. This man, whom Flavell (1963) refers to as "one of the most remarkable figures in contemporary behavioral science," has been studying children and their behavior for over forty years. His writings have been extensive and the research precipitated by his theory and findings has been enormous. In spite of this, Woodward (1963) points out that comparatively little of the work has been directed toward the area of mental deficiency. Piaget and his colleagues, with the exception of Inhelder (1944), have published very little about retarded children.

This is not meant to imply that Piaget does not envision his theory as being relevant to the area of mental deficiency. On the contrary, Piaget and Inhelder (1947) have addressed themselves directly to the need for change in the present approach to assessing mental retardation. They pointed out that present intelligence tests give only results or efficiency of mental activity without grasping the psychological operations themselves. "The concept of mental age is only a reference to a scale of average efficiency, and does not correspond to any natural phase of mental development" (Piaget & Inhelder, 1947).

They went on to suggest that rather than determining IQ, a more appropriate approach would be a more direct qualitative and genetic analysis of mental operations. For illustrative purposes, they described the building up of logical operations, pointing out that this is observed most clearly in the evolution of the child's notions of conservation, i.e.,his awareness that certain properties (quantity, length, number, etc.) remain invariant in spite of certain transformations. One of Piaget's approaches to studying the development of conservation has been to present the child with two identical balls of clay, transforming one of them into various shapes, and then asking the child whether the two still have the same amount of clay (conservation of mass). A similar procedure has been used to study conservation of weight and volume. It is not until the child reaches about the age of seven that he is able to conserve mass, with weight and volume conservation developing later, volume being the last to evolve.

It is because of the minimal amount of research directed at substantiating Piaget's findings on retarded populations that this study has been undertaken. Furthermore, it seemed appropriate to analyze those operations which Piaget himself feels most clearly illustrate the development of cognition, namely,the evolving of the conservation principles in the child's thinking during the subperiod of concrete operations. However, before discussing conservation further, it is necessary to first briefly review some of the main aspects of Piaget's theory of intelligence.

Piaget's Theory

First and foremost, Piaget (1952) defines intelligence as an adaptive process. But it is characterized as only a specific instance of adaptation, related to mental activity, since he asserts that adaptation is the basic underlying process involved in biologic activity at all levels. He defines adaptation as an equilibrium or balanced state between the action of an organism on the environment and vice versa (Piaget, 1950).

This involves two indissociable but antagonistic processes, labeled assimilation and accommodation in Piaget's system (Piaget, 1954). The former process incorporates the environment in terms of already existing organic structures, while the latter involves the organism modifying itself to the environment. Thus assimilation is egocentric and tends to subordinate the environment to the organism as it is, whereas accommodation is the changes the organism makes to the constraints of the environment. It is noteworthy that assimilation can never be pure because the incorporation of new stimuli into existing structures necessarily involves some modification of the stimuli (Piaget, 1930). Also, accommodation is only possible as a result of assimilation since the organism's adjustment can occur only in response to the assimilated material. The ontogenesis of intelligence is the result of the continual process of assimilation and accommodation being brought into equilibrium in mental activity.

However, Piaget's theory is above all a developmental one, and therefore involves a series of increments or levels of development which are the result of the achievement of various equilibration states. Piaget maintains that these various levels are attained in the same order for each individual. Three major levels or periods comprise the total developmental growth of intelligence in Piaget's theory:

(a) the period of sensori motor intelligence (birth to two years)

(b) the period of preparation for and organization of concrete operations (two years to eleven years)

(c) the period of formal operations (eleven years onward).

Each of these major periods is divided into a variable number of subperiods, stages, and substages (Flavell, 1963).

The period of primary concern for the present study is the second major period and more specifically the subperiod of concrete operations (seven to eleven years), since this is the level at which the child first develops and eventually generalizes and stablizes his ability to conserve. What the concrete operational child possesses which those of earlier stages do not are well organized cognitive systems which enable him to deal much more effectively with his environment. These "cognitive operations" as Piaget calls them are numerous and varied. However, that operation on which Piaget places the greatest import is "reversibility which is the fundamental property of operational structures" (Piaget & Inhelder, 1969, p. 202). Thus, Piaget maintains that reversibility, i.e.,the operation by which an action can be annulled in thought by an inverse action or compensated for by a reciprocal action, is a necessary prerequisite for the development of conservation.

Conservation Studies

Having taken this brief look at Piaget's theory and where conservation fits into his developmental outline, let us now survey some of the research concerned with conservation. To begin, a closer inspection of the results of Piaget's conservation studies is warranted. Piaget has stated that a child up to the age of seven systematically denies any conservation. At age seven to eight, the child begins to assert conservation of mass. However, it is not until age nine to ten that he can affirm with conviction conservation of weight, and eleven to twelve before he can conserve for volume (Piaget & Inhelder, 1947).

It has been previously mentioned that one of Piaget's techniques for studying conservation has been the use of two identical balls of clay, one of which was transformed into various shapes. However, it should be noted that Piaget's general experimental approach has been what is referred to as the "clinical method." In his studies, not all children were given the exact same task, nor was a given task administered exactly the same way to all children to whom it was presented (Flavell, 1963). Furthermore, considerable emphasis has been given to the child's explanations as far as ascertaining the presence of conservation. "In short we believe it important, not merely to grasp simple verbal notions, but to get down to the operational mechanisms of thought...encourage the child to give a reason for his statements" (Piaget & Inhelder, 1947, p. 402).

As a result of his experimental approach, Piaget's results have not generally been reported in statistical terms. Accounts of his research have frequently consisted of the verbal responses of a number of the children who served as subjects in his experiments, with discussions and generalizations based on these. Because of the lack of balanced experimental designs and statistical analyses of results, many researchers have felt the need to replicate Piaget's studies with more standardized procedures. Among those who have done so is David Elkind who has designed a number of studies based on Piaget's research. One of these was specifically intended to replicate Piaget's initial conservation study (Elkind, 1961a).

In this particular study, Elkind employed 175 children between the ages of 5 and 11, 25 at each age level, using exactly the same procedure for each child. Like Piaget, he took two identical balls of clay, making sure the children were convinced that each ball was identical. For conservation of mass, he first asked the child if both would have the same amount of clay after one of the balls was rolled into a "hot dog" (prediction question). Then after the actual transformation was performed, the child was asked if they both now contained the same amount of clay (judgment question), followed by "why is that?" (explanation question). The same procedure was used to test for the conservation of weight and volume, with the exception of the necessary rewording of the questions.

Elkind first analyzed the results to determine if the types of response, i.e.,prediction, judgment, and explanation, differed significantly from one another. Because this analysis did not approach significance, Elkind felt that all three types could be used as equivalent signs of conservation. Based on McManis' study, to be reviewed shortly, this hypothesis is questionable. Thus, with three types of response for each of the three conservations, each child was scored for a total of nine responses. Using an analysis of variance, Elkind found that type of conservation, age level, and the interaction between these two factors were all significant at the .01 level. Individual *t* tests showed these effects to be in the direction found by Piaget, with children attaining the highest conservation scores for mass and the lowest for volume, and an increase in scores with advanced age (Elkind, 1961a).

Elkind also analyzed the results to determine at what ages the children were conservers for mass, weight and volume. He used 75% correct responses as the criterion for the presence of conservation. He assumed Piaget used this figure to assess ages of conservation attainment in his initial study since it was used by him in later studies. Compared to Piaget's finding that conservation of mass was attained at age seven to eight, there was a slight discrepancy in that Elkind's subjects did not attain 75% success until age nine. Weight was comparable to Piaget's results with 75% of the responses indicating conservation at age ten. However, for volume only 25% of the responses indicated conservation in the eleven year old group. Elkind suggested that this low score may have been due to the fact that Piaget used the volume concept in relation to displacement of water, rather than as taking up more room which was used in his own study.

To further evaluate this discrepancy regarding age of attainment for volume conservation, Elkind performed another study using older subjects, ranging from 12 to 15 years of age (Elkind, 1961b). As in his previous study, his subjects were unable to conserve volume as early as Piaget had found. His results indicated that it was not until about age 15 that conservation of volume was well established. He therefore questioned Piaget's findings that conservation of volume is attained by age twelve.

In one other conservation study performed by Elkind (1961c), different types of material, sticks, liquids, and beads, were used to see how these were conserved. In addition to verifying his previous findings that type of conservation and age were significant factors, he also found that type of material significantly affects conservation performance.

One further point bears mentioning with regard to Elkind's studies. For the prediction and judgment responses, Elkind used the questions: "Will they both have the same amount of clay?...do they both have the same amount of clay?" (Elkind, 1961a). Both of these questions are suggestive of conservation, requiring the child only to respond affirmatively to obtain a conservation score. And yet these responses are given as much weighting as an accurate explanation of conservation. This point will be discussed further in relation to a replication of Elkind's study.

Lovell and Ogilvie (1960) performed a study dealing with conservation of mass. In this experiment they used the clay balls as did Elkind and Piaget. However, only judgment questions and explanations were asked of their subjects. Also, in order to be categorized as a conserver, a subject had to give both a correct judgment and an adequate explanation. Although this study was more concerned with the verbal explanations of the subjects, the results can be translated into age of conservation attainment based on Elkind's 75 % success criterion. These subjects, like Elkind's, did not attain conservation of mass until age nine.

Uzgiris (1964), in addition to using clay balls to ascertain the presence of conservation, used three other materials: metal nuts, wire coils, and plastic wire. She performed three different transformations on these materials for each of the three conservations. The "conservers" were defined as those children who not only were correct on all three transformations for any given material, but gave satisfactory explanations as well. Her results were supportive of Piaget's and Elkind's findings, with significance attained for age and type of conservation, as well as the interaction of the two. In addition, she found that type of material was a significant variable. Although the conservation of mass, weight, and volume were attained in the same sequence with any given material, there was not a coordination of steps in the conservations across different materials in any one individual. However, the variations were not systematic, and no single material consistently surpassed or lagged behind the others.

With regard to the ages at which conservation was achieved, Uzgiris stated that those found in her study agreed with Piaget for mass and weight. However, only 20% of the sixth graders, with a mean age of 12-2, were able to conserve volume. This is comparable to the 25% conservation Elkind found among his sixth grade subjects (Elkind, 1961a). But Uzgiris did use jars of water to illustrate volume in terms of displacement of water. Thus, differences in procedure as an explanation for the discrepancy with Piaget's findings is not applicable as in Elkind's study.

Another researcher, Jan Smedsland, has performed a series of experiments, involving some training and extinction procedures, aimed at examining the processes involved in the acquisition of conservation (Smedsland, 1961a-f). He found that children could in fact learn to give conservation responses after an initial training period. However, when exposed to extinction procedures, these children were much less resistant to reverting to a nonconservation state than those who were conservers before the training occurred. One of Smedsland's (1961f) studies involved the use of different materials, and the results indicated that training on discontinuous materials is more likely to produce a transition to conservation than practice on continuous materials.

Smedsland's overall impression from his studies was that conservation does not appear to be learned as a product of external reinforcements, but rather is the result of an internal conflict arising in the child's thinking processes (Smedsland, 1961e).

Retardate Conservation Studies

The aforementioned studies on conservation have dealt only with children of normal intelligence. There have been only a limited number of conservation studies involving retarded subjects. The first to be reported was a study done by Piaget's colleague, Barbel Inhelder (1944), who tested residents of an institution for the mentally retarded. Her general procedure was very similar to that which she and Piaget used with normals, i.e.,with no rigidly systematic set of experimental procedures. However she did use scales to demonstrate weight concepts and frequently performed three transformations of the clay ball: rolling it into a cylindrical shape, flattening it into a cake, and breaking it into pieces.

Inhelder's results were not quantified, her report of the study being comprised of the actual verbal responses of the subjects with discussions centered around them (Inhelder, 1968). Among those retardates to whom she administered the clay conservation tasks, she did find some who were able to conserve for mass and a few who could conserve for weight. But none were able to conserve for volume. Based on the performance of these mentally retarded subjects, Inhelder's overall impression was that the thinking processes of retardates develop in a similar fashion to those of normals, but with delays and fixations of development at various cognitive stages. As she and Piaget later stated, "But in the backward mind, this construction, while following the same rule of application, follows a much slower rhythm and remains forever unfinished" (Piaget & Inhelder, 1947).

In a more recent study, McManis (1969) set up an experiment designed to compare normals and retardates on conservation tasks. He took a group of 90 retarded children and matched them for mental age with a similar number of normal children. The mental age range was 5-0 to 11-9 in the retarded group based on the 1960 Stanford-Binet (form L-M). The normal children's mental ages ranged from 5-3 to 11-11, derived from the Lorge-Thorndike IQ scores and the chronological age, with the exception of the five-year-old group in which the chronological age was used to represent the mental age.

His experimental procedure was set up by design very similar to Elkind's (1961a). He used the exact wording for the prediction and judgment questions as well as asking for explanations. He also used the same scoring technique, using all three responses as equivalent indicators of conservation.

McManis' results agreed with previously discussed studies, with type of conservation and, in this case, mental age being statistically significant. Although the type of conservation X mental age interaction was also significant, it is important to note that one source of this interaction effect was an inverse relation between mental age and conservation of volume, quite the contrary of previous studies. There were reversals found among individual subjects with regard to the sequential order in which conservation was attained, i.e.,some attained higher scores on volume than mass or weight. Thirteen normals and eleven retarded subjects, all in the younger mental age groups, exhibited these reversals. McManis attributed this incongruity to what he felt were probably spurious conservation predictions. He thought that the children in the lower mental age groups were not able to foresee the effects of transformations as the older children. Thus, he questioned the adequacy of prediction questions for revealing their thinking processes. He felt that these questions produced misleading responses more indicative of the lack of understanding of the young children rather than their ability to conserve.

However, examination of the 24 reversals found among the younger subjects revealed that only half occurred on prediction responses. So the prediction questions alone do not account for the incongruous results. A more plausible explanation might be the wording of both the prediction and judgment questions. Having replicated Elkind's design, McManis worded these questions so that a simple affirmative reply was scored as a conservation response. It is certainly questionable that this is the best way to ascertain the presence of conservation since many children, when confronted with a question they cannot answer, will answer in agreement to the question stated. Whether this may have occurred in Elkind's study as well is not ascertainable since he did not report the raw scores for the three types of responses (Elkind, 1961a).

With regard to the comparison between the two IQ groups, McManis found differences in performance on all three types of conservation, varying both in direction and amount. The normals scored significantly higher for mass, but exceeded the retardates only slightly and to a nonsignificant degree for weight. On the other hand, for volume the retardates actually exceeded the normals, and to a significant degree. McManis pointed out that this difference was due to the greater number of correct conservation predictions given by the retardates. Again, the wording of the questions may have been the causal factor for this unexpected result, assuming the retardates may have been more prone to answer "yes". The present study, like McManis', presented three conservation tasks to a normal and a retarded group matched for mental age. However, in order to avoid some of the problems experienced by McManis, the children were not asked to predict the outcome, but only make judgments after the actual transformation. Furthermore, the questions presented did not require a "yes" or "no" response. Rather, the children were presented all three of the possible alternatives in a conservation problem, and required to select one of the three.

Other Retardate Studies

Although studies comparing normals and retardates on conservation tasks are limited, there has been a good deal of research comparing their performances on other types of conceptual tasks, a few of which warrant a brief mention here. Milgram and Furth (1963) matched groups of retardates with normals at four mental age levels: 5-8, 7-0, 8-3, and 9-9. They presented both IQ groups with three different tasks, two of which were described as basically perceptual in nature and the third designated as a conceptual task. They felt that retardates are limited in their ability to utilize language experience in the conceptual grasp of situations and problems. They therefore predicted that the performances of the two IQ groups would differ significantly only on the conceptual task. Their results supported this hypothesis. The performances on the perceptual tasks were not significantly different for the two groups, but the retardates' scores on the conceptual task were significantly lower than the normals'.

Myers et al. (1961) matched normals and retardates at a mental age of six years and presented each with a battery of 13 tests, which included psychomotor, perceptual speed, vocabulary, and reasoning tasks. They found that the retardates performed most poorly on the reasoning tasks when compared with the normals, while on the linguistic or vocabulary tests, some retardates actually surpassed the normals. Myers et al. felt that for tasks that require cumulative experience or the accumulation of bits of easy information, retardates matched for mental age with normals may perform as well and at times better than normals because of their advanced chronological age and resultant more prolonged exposure to environmental experiences. On the other hand, on those tasks which require the ability to deal with complexity, the retardates are not able to perform at the same level as normals matched for mental age.

Hood (1962) matched normals and retardates at five mental age levels between four and nine years. He compared their performances on eight tasks, all of which involved number concepts except for one which dealt with conservation of displaced water. His findings revealed that the retardates had developed operational thought processes, indicated by their responses on these tests, but this development occurred at a much slower rate than for the normals. For example, he found that between the mental ages of six and eight, the proportion of conceptual responses in retardates increased only 25%, while for normals this figure was nearly 70%.

On the same subject, Kenneth Lovell (1966), while discussing the developmental approach of Jean Piaget, agreed that some retardates are able to perform at the concrete operational stage. However, he maintained that the learning they employ consists of a linear sequence of action and first order operations. Based on his observations and numerous studies on retarded children attending the ESN Special School in England, he stated that the cognitive structure of a retarded child and a normal child of the same mental age is considerably different. He exemplified this by asserting that at the mental age of nine the ordinary child has much more flexibility in his first order operations than a mentally retarded child, and the understanding of the normal child extends over a wider area.

Problem and Hypotheses

The matter discussed immediately above was the primary concern of the present study. Do retardates, matched for mental age with normals on present intelligence tests, perform as well as normals on tasks requiring operational thought processes? Or is the cognitive structure of those with a low IQ such that in spite of their advanced chronological age, they are functioning at a lower level of operational thought than normals with equal mental ages? In an attempt to examine these questions, normal and retarded subjects were matched for mental age in the age range defined by Piaget as the period of concrete operations, namely, seven to eleven years. Divided into two mental age levels, higher and lower, they were administered three conservation tasks: mass, weight, and volume. The following results were expected from the present study.

In light of previous conservation studies which have shown age and type of conservation to be significant factors affecting performance on conservation tasks, it was expected that:

1) subjects at the higher mental age level would have significantly better scores than those at the lower level.

2) the scores for mass would be significantly greater than those for weight, and the weight scores would significantly exceed those for volume.

But more directly related to the purpose of this study was the comparison of the performance of the normal and retarded groups. Based on the studies discussed above which found retardates, matched for mental age with normals, less able to perform on conceptual tasks, it was also hypothesized that:

3) the retarded group would have significantly lower conservation scores than the normal group matched for mental age.

With regard to the types of conservation, some specific differences were also expected. This was based not only on the specific ages at which mass, weight and volume have been found to evolve in conservation studies with normals, but also on the hypothesized difference in rate of development of operational thought processes between the two IQ groups. Because the lower mental age range (seven to nine years) was below that age at which volume conservation has been found to evolve (eleven years onward), it was expected that:

4) at the lower mental age level, the mean difference in scores between the normals and retardates would be significantly greater for mass than for volume.

The reverse was expected at the higher mental age level. In spite of the hypothesized slower rate of operational thought development for the retardates, it was assumed that most would have achieved conservation of mass at the higher mental age level (ten to eleven years). Furthermore, based on Inhelder's (1968) observation that not a single retarded subject was able to conserve volume among those she tested, it was hypothesized that:

5) at the higher mental age level, the difference in scores for volume between the two IQ groups would be significantly greater than the difference for mass.

Finally, on the basis of Hood's (1962) results indicating that the rate of development of operational thought processes for normals was greater than for retardates matched for mental age, it was hypothesized that:

6) the mean difference between the scores of the normal and retarded groups would be significantly greater at the higher mental age level than at the lower level.

EXPERIMENTAL DESIGN

Subjects

The retarded group consisted of 30 residents of an institution for the mentally retarded (Sunland Training Center at Gainesville, Florida) with a major medical diagnosis of Familial Retardation. This group had an IQ range of 58 to 73 with a mean IQ of 66. These scores were obtained from previous testing done by staff psychologists at Sunland, using either the Stanford-Binet or the appropriate Wechsler intelligence test. These Ss were divided into two mental age levels, the lower level (n = 15) with a mental age range of 7-1 to 9-7 and a mean of 8-7. The higher level (n = 15) was comprised of those with a mental age between 10-0 and 11-6 with a mean of 10-10. The chronological ages ranged from 12-0 to 23-11 for this retardate group.

The mental ages were derived from the Pinneau Revised IQ Tables (Terman & Merrill, 1960), based on the particular IQ score and chronological age for each retarded subject. The only exceptions were those whose chronological age was above 18, in which case the highest age in the tables (18) was used. Although the Pinneau tables were constructed for use with the Stanford-Binet, the use of these tables as an estimation of mental age from Wechsler IQ scores was based on the fact that both tests yield deviation IQ's with a mean of 100, and have standard deviations of 16 and 15 respectively.

Furthermore, general correlational studies between these two tests reveal _r_'s between .74 and .89 (Cohen & Collier, 1952, _r_ = .85; Estes _et al._, 1961, _r_ = .74; Holland, 1953, _r_ = .87; Krugman _et al._, 1952, _r_ = .817; Pastovic & Guthrie, 1951, _r_'s = .85 & .80; Weider _et al._, 1951, _r_ = .89). The correlations hold for retarded populations as well, the _r_'s ranging between .77 and .91 (Fisher _et al._, 1961, _r_ = .77; Nale, 1951, _r_ = .91; Sandercock & Butler, 1952, _r_ = .76). A spot check, using WISC IQ's to determine mental age by means of Wechsler's mean-average approach (Wechsler, 1951) and comparing them to the Pinneau table mental ages, revealed that most of the Wechsler derived mental ages fell within two or three months of the Pinneau mental ages.

The normal group was comprised of 30 students attending the University of Florida Laboratory School (P.K. Yonge). The mean IQ for this group was 101, with the scores ranging from 93 to 116, as determined by the California Test of Mental Maturity (CTMM), Short-Form. They were matched for mental age with the retarded _S_s, and likewise divided into two mental age groups, with 15 students in each group. The mental ages given by the CTMM have been derived in the exact manner as the Stanford-Binet. "The mental age tables and the test manuals may be used interchangeably with those in the Binet manual (the Pinneau Tables)..." (Sullivan _et al._, 1963 CTMM Examiner's Manual).

The use of the CTMM derived mental ages of the P.K. Yonge students as an approximate means for matching them with the retardates was also based on correlational studies. Altus (1955) found a correlation of .77 between the WISC and CTMM, while Sheldon's (1954) results indicated a correlation of .702 between the Binet and CTMM. Furthermore, Stake & Mehrens (1960) found no significant difference between the mental ages obtained by the same group of children on the CTMM and the WISC.

Materials

Nine pairs of clay balls, each 1.5 inches in diameter, were used in this study. This allowed the use of a new pair of clay balls for each of the nine transformations, thus preventing any confusion on the part of the Ss which might result if the same balls were used throughout. In addition to the clay balls, four unequal lumps of clay were used to demonstrate the meaning of the terms "more clay" for mass conservation, and "more room" for volume conservation.

A balance scale was used for showing that the clay balls weighed the same for weight conservation. It was also used with a clay ball and a hollow glass ball to demonstrate the meaning of the word "heavier" in terms of making the scale go down.

Two identical glass jars of colored water, with graduated markings on the side, were used to demonstrate the concept of volume as "taking up room". A knife was used to cut a clay ball in half as one of the transformations. A Cassette tape recorder was used to record the testing sessions to insure that the explanations given by the Ss would be accurately categorized.

Procedure

The Ss were tested for conservation of mass, weight, and volume, presented in a predetermined random order. For each conservation three trials were given, each trial consisting of a different transformation of one of the two balls of clay presented at a time. In the first transformation it was rolled into a cylindrical shape approximately four inches long. For the second, it was flattened into a pancake shape approximately three inches in diameter, while the third transformation consisted of cutting a ball in half. The transformation order was the same for each of the three conservations, and a total of nine trials was administered to each S.

For conservation of mass, S was first shown two unequal lumps of clay and asked which one had more clay. This was to insure his understanding of the phrase "more clay". All Ss correctly identified the larger lump. Then S was shown two identical balls of clay and told that both had the same amount of clay. S was asked if he agreed, and if not, clay was added or subtracted until S felt they had the same amount. E then gave one ball to S and rolled the other into a cylindrical shape, and asked "Now do you have more clay, do we both still have the same amount of clay, or do I have more clay?" After S responded, he was asked why he made his particular choice. The same procedure was followed for the following two trials except that for the second, E flattened one ball into a pancake shape, and for the third cut a ball in half. Also, the order in which the three alternative questions were asked was varied so that for each trial a different order was presented.

For conservation of weight, S was first handed a clay ball and a glass ball simultaneously to feel the weight difference, and then shown that the heavier clay ball lowered the balance scale when both were placed on it. Then two identical clay balls were shown to balance the scale. E then gave one of these to S, transformed the other into a cylindrical shape, and asked "Now, if I were to put both of our clay back on the scale, is yours heavier, would yours make the scale go down? Or do they both still weigh the same, would the scale stay at the same level? Or is mine heavier, would mine make the scale go down?" After asking S to explain his choice, the second and third transformations were performed, with only the order of the questions being altered.

For conservation of volume, the concept of "taking up more room" was first demonstrated by placing two lumps of clay conspicuously discrepant in size each into a jar of colored water. After pointing out to S that the larger lump takes up more room because it makes the water rise higher in the jar, two identical balls were placed in the jars to illustrate that they make the water rise to the same level. Then S was tested in a fashion similar to the weight conservation tasks, except that the phrases "take up more room" and "make the water come up higher" were used. The exact procedure and verbatim instructions are given in Appendix A.

RESULTS

The Ss received a score of 1 for each conservation response, i.e., for each correct answer of "same" when presented the three alternatives after the transformations. For each incorrect response in which E's or S's clay was judged "more", a score of 0 was assigned. Thus, the range of scores for each S at each type of conservation was 0 - 3. The raw scores for each S are given in Appendix B. The mean scores and the standard deviations for the four subject groups (n = 15) at each type of conservation are given in Table 1 below.

Table 1. Means and Standard Deviations of Conservation Scores

	Lower (M.A. = 7 to 9)		Higher (M.A. = 10 to 11)	
	Mean	Standard Deviation	Mean	Standard Deviation
Normals				
Mass	2.73	.46	2.87	.48
Weight	2.27	1.23	2.53	.73
Volume	1.47	1.19	2.13	1.15
Combined Mean	2.15	.96	2.51	.79
Retardates				
Mass	1.13	1.15	2.27	.76
Weight	0.73	.86	1.13	1.03
Volume	0.47	.61	1.00	1.03
Combined Mean	0.73	.87	1.47	.94

To test for the significance of the three main factors: IQ Level (normals and retardates), Type of Conservation (mass, weight, and volume), and Mental Age Level (lower and higher), a three-way analysis of variance with one repeated measure (Type of Conservation) was employed following Kirk's (1968, p. 283) split-plot design. The results of this analysis are given in Table 2, showing that the F ratios for all three main effects proved to be significant. Furthermore, none of the interaction effects approached significance.

Table 2. Summary Table for the Analysis of Variance of Conservation Scores.

Source	Sum of Squares	Degree of Freedom	Mean Square	F
1 Mean	537.339	1	537.339	
2 A(IQ Level)	66.006	1	66.006	40.12**
3 C(MA Level)	12.272	1	12.272	7.46*
4 B(Type)	29.344	2	14.672	25.784**
5 AC	1.249	1	1.249	0.76
6 AB	1.478	2	.739	1.29
7 CB	0.811	2	.405	0.71
8 S(AC)	92.131	56	1.645	
9 ACB	2.633	2	1.316	2.31
10 SB(AC)	63.730	112	.569	

*p < .01
**p < .001

The combined means for the levels of each factor are given in Table 3. As can be seen in this table, the difference between means for the two mental age levels was in the expected direction.

The higher mental age subjects' scores were greater on the average than those for the lower mental age subjects, thus confirming the first hypothesis. Likewise, those Ss in the normal group performed better on the average than the retardates, confirming hypothesis 3.

Table 3. Combined Mean Conservation Scores for Levels of the Three Experimental Factors.

IQ Level	(Normals)	2.33
	(Retardates)	1.12
Type of Conservation	(Mass)	2.25
	(Weight)	1.67
	(Volume)	1.27
Mental Age Level	(Higher)	1.99
	(Lower)	1.47

Although the means for Type of Conservation were in the hypothesized direction, mass > weight > volume, pair comparisons among these means were made to determine which differences were significant. Because these comparisons are nonorthogonal in nature, Dunn's multiple comparison procedure was used (Kirk, 1968, p. 79). The difference between the means for mass and weight was .58, which is greater than Dunn's critical value at the .01 level. The difference in mean scores for weight and volume was .40, which is significant at the .05 level. Thus, the second hypothesis was also verified, with the scores for mass significantly exceeding those for weight and the weight scores significantly greater than those for volume.

To test hypothesis 4 , a t test was employed to determine whether the difference in mean scores for the retardates and normals was significantly greater for mass than for volume at the lower mental age level. Although this value was in the hypothesized direction, with the mean difference for mass exceeding that for volume by .60, it was not significant. The same procedure was used to test hypothesis 5, determining whether the difference in normal and retardate mean scores for volume exceeded that for mass at the higher mental age level. Again, the value was in the hypothesized direction, with the volume difference exceeding mass by .53, but this also did not yield a significant $\underline{t}$ value.

To further analyze the differences within both of the above sets of four means, pairwise comparisons were made. At the lower mental age level, the normal and retardate mean difference for mass was 1.60 in favor of the normals as expected, and this figure proved to be significant at the .01 level. But the difference for volume between these two groups was 1.00 with the normals achieving the higher score, and this also was significant at the .01 level. This latter difference was contrary to one of the premises for hypothesis 4, and as a result it was not verified.

A similar situation existed at the higher mental age level. As anticipated, the difference for volume between the two IQ groups was 1.13, the normals attaining a significantly greater mean score. But a difference in favor of the normals of .60, significant at the .05 level, resulted between the two groups for mass as well. This being contrary to a premise for hypothesis 5, this hypothesis likewise was not confirmed.

One further comparison had been planned, to test hypothesis 6, involving the difference between the normals' and retardates' combined mean scores for all three types of conservation at the lower mental age level compared to the difference at the higher mental age level. However, the difference between the two groups at the lower mental age level (1.47) actually exceeded that at the higher mental age level (1.05). The fact that this difference was in the opposite direction predicted by hypothesis 6 made a statistical comparison unnecessary.

In addition to the above a priori comparisons, one a posteriori test was conducted. It was noted that the mean score for the normals at the lower mental age level not only was greater than the retardates' at the same level, but also surpassed the retardates' mean score at the higher mental age level. Tukey's procedure (Winer, 1962, p. 87) was employed to see if this difference was significant. Although the outcome of the test was not significant, it did very closely approach significance ($p < .06$).

An inspection was also made of the explanations given by the Ss for each judgment. These were placed into two categories, conservation and nonconservation. Those explanations which were categorized as conservation included a fairly wide range of reasons. Some pointed out the irrelevance of shape in affecting the mass, weight or volume. ("No matter what shape, they're the same"; "No matter if you cut it into eight parts, it would still be the same".) Some Ss were not as general in pointing out the irrelevance of shape, but focused on the fact that the particular transformation only changed the shape. ("You just flattened it out"; "You pressed it down and it looks different, but it still weighs the same".) Quite a few subjects emphasized the fact that no clay was added or taken away. ("You didn't put any more clay in"; "Because you didn't throw any away".) Still others pointed out that a reversal of the process would result in the same two balls. ("Well you cut it in half, but if you put it together, it would still be the same as this".) And just a few subjects observed that although one dimension was increased with a transformation, another was decreased. ("It might be longer, but it's thinner in width than mine".)

Any explanations which did not clearly indicate an understanding of the conservation principle were categorized as nonconservation. Thus, in addition to the obviously wrong perceptual responses ("That one's bigger"; "Yours is longer"), any vague or ambiguous explanation for a correct judgment was also categorized as nonconservation. The number of conservation explanations given by each subject is reported in Appendix B.

To examine these data for differences between the normals and retardates, the number of correct judgments and conservation explanations was totalled for both IQ groups. For the normals, the number of correct judgments was 210, with conservation explanations given for 186 of these judgments. The number of correct judgments given by the retardates totalled 101, with only 63 conservation replies. Looking at these figures in terms of percentages, only 11% of the normals' correct judgments were not followed by a conservation explanation, while for the retardates this figure was 38%.

The data in Appendix B were further inspected to determine the number of conservers in each of the IQ groups. A conserver was defined as an S who not only gave the correct alternative for all three transformations of any one of the three types of conservation, but also gave a conservation explanation for each of these correct judgments. In the normal group, 23 Ss were conservers for mass, 18 for weight, and 10 for volume. Among the retardates only 7 Ss conserved for mass, 2 for weight, and 2 for volume. Furthermore, in the lower retardate group, only 1 S was a conserver for any of the types of conservation, while 10 of the low normals were conservers for one or more of the types. In determining the number of Ss who were conservers for all three types of conservation, it was found that 9 normals, 4 at the lower mental age level, achieved this. Only 2 retardates were conservers for all three types, neither of whom was in the lower group.

DISCUSSION

To facilitate the following discussion, the specific hypotheses will be dealt with in the order in which they were initially stated. As has already been shown, mental age was found to be a significant factor, with those Ss in the higher mental age group attaining the greater conservation scores. Although the conservation research reviewed in this study showed chronological age to be a significant factor, it was felt that this would apply to mental age as well. This was based on the fact that those studies used normal children, and in a normal population chronological age and mental age obviously have a high correlation since by definition a child of normal intelligence is one whose mental age and chronological age are in close agreement. This result supported Piaget's theory that conservation is attained in a chronological developmental sequence.

The results for type of conservation support Piaget's findings concerning the actual order of attainment for the three conservations, with the scores for mass significantly greater than those for weight, and the weight scores significantly greater than those for volume. This was not only true for the overall means, but for the mean scores of each of the four subject groups as well (Table 1). This result seems to support the use of the testing procedure employed within this study rather than that used by McManis (1969) requiring "yes" or "no" responses from the Ss.

The above is not meant to imply that no individual Ss exhibited reversals in this sequence. There were a few Ss who attained a higher score for weight or volume than mass, or a higher volume score than weight. But these generally involved correct judgments given without conservation explanations, and therefore were probably due to an occasional correct guess on the part of the Ss

However, there were two of the 60 Ss, both in the high normal group, who were conservers and yet had reversals. This is definitely contrary to Piaget's position that all children attain the conservations in the same order. For this reason, a closer inspection was made of the explanations given by these two children. In the one case, a 10-6-year-old boy conserved for mass and volume, but not weight. Upon examining his explanations for weight, it was apparent that he was trying to apply more advanced principles of physics to the problem, confusing weight with center of gravity. It seemed as though he was attempting to solve the problem using more advanced formal operations, dealing with gravity and the forces it exerts. But because his understanding at this level was incomplete, or as Piaget would say, not yet in a state of equilibrium, the resultant confusion led to incorrect judgments and explanations on the concrete operational task presented him.

The second case involved a 10-0-year-old boy who was a conserver for weight, but not mass or volume. Examination of his explanations did not readily suggest a reason for this reversal. However, it was noted that the order for presenting the conservation tasks to this subject was such that weight was the last administered.

It may have been that this boy was functioning at a level between nonconservation and conservation, referred to as the transitional period by Piaget. It is at this time that a child is beginning to develop the operations necessary for conserving, but has not yet achieved the equilibrium required for asserting conservation at all times under all conditions. So the experience of having been given the mass and volume tasks previously might have been a sufficient source of stimuli for this boy to fluctuate to a conservation state for weight at the time it was administered. If this in fact was the case, it would support the use of a random order for presenting various conservation tasks rather than the mass, weight, volume sequence used by most other researchers.

One of the more noteworthy results of this entire study was not the fact that the major hypothesis was confirmed with the normals' performance on the conservation tasks significantly surpassing that of the retardates', but rather the extent of this difference in performance. And the difference was not just exhibited by the actual conservation scores, in which the normals exceeded the retardates beyond the .001 level. Appendix B reveals that all but three of the normals were conservers for at least one of the three types of conservation, while only seven of the entire group of thirty retardates were able to accomplish this. Furthermore, nine of the normals were conservers for all three conservations, four of whom were in the lower mental age group, while only two retardates conserved each type, both of whom were in the higher mental age group.

The percentage of correct judgments with conservation explanations showed that most of the normals verbally expressed an understanding of conservation in addition to giving a correct judgment. This was not true for the retardates, since 38% of their correct judgments were not followed by a conservation explanation. Although this finding might further suggest the superiority of the normals in conserving, it should be kept in mind that this might have been partly due to the retardates' restricted ability to verbalize their thoughts rather than an indication of an actual lack in understanding conservation. This possibility is supported by the results of a study by Kates (1968) comparing the use of logical symbols in deaf and hearing subjects, which led her to conclude that "the development of skill in certain mental operations must precede the ability to describe verbally the logical symbolic expression correctly" (Kates, 1968, p. 12).

But even with the elimination of adequate explanations as a criterion, only three additional retardates had all three judgments correct to warrant classification as a conserver. None of these Ss gave three correct judgments for all three types of conservation. Thus, the superiority of the normals as measured by the number of conservers cannot be attributed to the inability of the retardates to verbalize conservation.

Probably the most significant indication of the great disparity in performance between the normals and retardates was the fact that the lower normal group not only exceeded the lower retardate group, but their total mean score was also greater than that of the higher retardates, very closely approaching significance ($p < .06$). This superiority also existed for the means of each type of conservation (Table 1).

However, the disparity between the two IQ groups was not entirely a function of poor performances by the retardates. In comparing the normal group to those in other conservation studies, it was observed that their abilities were in some cases more advanced. This was particularly exemplified by the volume scores for the lower normals. Although previous studies indicated that volume was attained at eleven years onward, almost 50% of the judgments given by this seven to nine year group were correct for volume conservation, with four of the subjects actually achieving a conserver classification. On the other hand, only 16% of the lower retardates' judgments were correct for volume, and the difference between the two groups was statistically significant at the .01 level. Because one of the premises for anticipating the lower normals to achieve greater superiority for mass than volume over the lower retardates was that both groups would do poorly on volume, hypothesis 4 was not confirmed.

Based on conservation research indicating that conservation of mass was generally achieved by age nine, one of the premises for hypothesis 5 was that in the ten to eleven group the retardates would have generally achieved conservation of mass. However, at the higher mental age level only 6 of the 15 subjects were conservers for mass, while for the normals at this mental age 13 of 15 were conservers, resulting in a significant difference in favor of the normals. This being contrary to one of the premises, hypothesis 5 was not verified. Even though the normals attained significantly greater scores for volume than the retardates, the difference for volume was not significantly greater than the difference for mass between the two IQ groups at the higher mental age level.

One further unexpected finding was the fact that the retardates actually showed more improvement between the lower and higher mental age levels than did the normals. This was quite the opposite of hypothesis 6, based on Hood's (1962) results indicating that the rate of development in conceptual thinking for normals was greater than that for retardates. However, upon examining the number of conservation responses given by the lower normal group, it was noted that for mass 91% of the judgments indicated conservation, while for weight this figure was 76%, and for volume almost 50%. This degree of success by the lower normal group did not leave much room for the higher normals to improve upon, particularly for mass and to a lesser degree for weight. Because the lower retardate group performed so poorly, it took but a mediocre performance by the higher retardates to produce a sizeable improvement in the mean score. So it does not appear that the retardates' greater improvement in mean score was indicative of a more rapid rate of development on their part, but rather of a ceiling effect produced in the normal group because of the advanced performance of the lower normals.

Having discussed the outcome of the various hypotheses, one question immediately comes to mind. What is it about the retardates' thinking processes that, in spite of scoring at the same level as normals on present intelligence tests, they are unable to perform comparably to normals on the conservation tasks? In light of her research with retardates, Inhelder (1968) has set forth a theory concerning their delayed and unfinished development of thought processes as indicated by their conservation performances. She maintains that some retardates do achieve various stages of equilibrium for concrete operations since they have been shown to conserve for mass and occasionally weight. However, she differentiates this equilibrium developed by retardates from normals, maintaining that theirs still retain some of the intuitive or perceptive elements of developmentally earlier thought processes. Because of this "pseudo-equilibrium" state, the retardates are not as readily able to expand their operations as normals, who achieve a more transitory or mobile state of equilibrium. As a result, there is a lag in the evolution of the thought processes of the retardate. She also points out that conservation of weight is one more step removed than mass as far as accessibility to intuitive thinking. Hence, the retardates with their intuitive biased pseudo-equilibrium are slower in developing the necessary operations to conserve for weight.

One further claim made by Inhelder is that conservation of volume is a task completely removed from any intuitive analysis. As a result, one has to attain the level of formal operations before conservation of volume is possible. This level is considered unattainable for retardates by Inhelder and Piaget (1947) because their operations contain residual intuitive elements. Therefore, by definition, anyone who attains conservation of volume is not a mental retardate by their criteria. The above theory is such that it is not readily amenable to direct verification. However, a cursory inspection of the explanations given by the subjects in this study did reveal that the retardates' reasoning was much more perceptually oriented than the normals'.

It might be asked what implications the present findings have for the area of mental retardation. Piaget and Inhelder (1947) have long maintained that it is far more meaningful to evaluate a child on a scale of development based on operations or thinking processes rather than present methods. The present study supports the position that the two approaches do not produce similar assessments. For example, some of the retardates in this study with a mental age of eleven years were not conservers even for mass. So by Piaget's operational scale, they would be considered as functioning intellectually at a level below seven or eight years of age.

More research is needed to assess just what a determination of this kind would mean in terms handling the child. For instance, how would the above mentioned retardates with a mental age of eleven years and an operational stage of six years compare to the two retarded Ss in this study who were conservers at each conservation in terms of more general adjustment skills and learning abilities? On the surface, it would appear that there would be some differences. If this were the case, it would seem that this might have implications as far as curriculum planning for those who are attending special education classes.

More research also seems warranted with regard to the effectiveness of training techniques. Can retardates who have begun the development of concrete operations be exposed to experiences which might enhance the continued evolution of these operations? Although Smedsland's (1961f) training procedures produced only tenuous changes in the conservation performance of the Ss, this training was short in duration and limited in scope. What if similar but broader techniques were presented repetitively over a period of time? It is hoped that the present study will serve to stimulate further research along these lines since it could have some far reaching effects in the area of mental retardation.

SUMMARY

Piaget's theory of cognitive development has been the source of a great deal of research, particularly in the area of conservation attainment. A review of the literature revealed that few of the previous studies in this area involved mentally retarded subjects. Because of the sparsity of research aimed at examining retardates in relation to Piaget's findings with normals, the present study was undertaken.

In this study, 30 mental retardates, divided equally into two mental age groups (seven to nine and ten to eleven years) were matched with an equal number of normals for mental age. Both IQ groups were presented three types of conservation tasks, mass, weight, and volume, using the initial technique employed by Piaget, i.e. the transformation of one of two identical clay balls. However, the present method differed in that the subjects were required to select one of the three possible judgments presented to them after a transformation, and then explain the reason for their choice.

The results, in addition to supporting previous studies concerning the significance of age and type of conservation as variables affecting conservation performance, confirmed the major hypothesis of this study. The normals attained significantly higher conservation scores than the retardates. An unexpected finding was the extent of the disparity between the normal and retardate performances.

This was due to both the poor performance of the retardates and the somewhat advanced performance of the normals. As a result, the latter three hypotheses in this study were not verified.

The results of the present study were related to Inhelder's theory for the developmental lag of retardates. Also discussed was the relevance of the present findings to the area of mental retardation.

APPENDICES

Appendix A

Exact Procedures and Verbatim Instructions for Administering Conservation Tasks

S was lead into the examining room and seated in a chair opposite the table from E. "I guess you are wondering why you are here today. Well, we are going to be playing a kind of game using clay. We will be doing a lot of different things, and it would be hard for me to explain everything to you at one time, so why don't we just get started and I'll explain to you as we go along."

Conservation of Mass

"First of all (Now) here are two lumps of clay." E then brought two unequal lumps of clay from underneath the table and placed them in front of S. "Can you tell me which one of these two lumps of clay has more clay in it?" After S responded, E stated, "That's right, this one does have more clay than the other one." (All of the Ss answered this question correctly.) "Now I have here two balls of clay. They both have the same amount of clay in them. Do you agree that they both have the same amount of clay?" If S disagreed, clay was added or subtracted from the balls until he agreed that they both contained the same amount of clay. "Okay, now I'm going to give you one of these two balls and you watch what I do to mine." E then rolled one of the balls into a cylindrical shape approximately four inches long. "Now do you have more clay, or do we both still have the same amount of clay, or do I have more clay?" And after S responded, E asked, "Why is that?" After removing this first pair, two more balls were brought into

Appendix A (cont.)

view. "I have here two more balls of clay that have the same amount of clay in them. Do you agree that these two balls have the same amount of clay?" Again if S did not respond affirmatively, the same procedure as before was followed. "Here, I'll give you one of these balls and I want you to watch closely what I do to mine." E then mashed his ball of clay into a flat pancake approximately three inches in diameter with the palm of his hand. "Now let me ask you, do we both still have the same amount of clay, or do you have more clay, or do I have more clay?" After responding, S was asked "Why is that?" Once again E brought two more balls into view and said "These two balls have the same amount of clay also, do you agree?" A negative response was handled as before. "Okay, here's one for you, and watch what I do to mine this time." E then picked up a knife and cut his ball in half. "Now do I have more clay, or do you have more clay or do we both still have the same amount of clay?" "Why is that?"

Conservation of Weight

"Now (First of all) I want to show you something." E then placed a balance scale on the table. "Here is a scale. Do you know what a scale is? Well, let me show you how this scale works. I have here two balls." E then brought two balls up onto the table, one made of clay and the other a hollow glass ball. "I want you to take these two balls, one in each hand, and tell me which is heavier." After S responded (all Ss answered correctly), E went on "That's

Appendix A (cont.)

right, that one is heavier. Now watch what happens when I put them on the scale, one on each side. You see the heavier clay ball makes the scale go down. That's how this scale works. When you put two objects on the scale, the heavier one makes the scale go down. Alright, now let me show you what happens when I take two balls that weigh the same and put them on the scale. Here are two clay balls that weigh the same." E placed two identical clay balls on either side of the scale. "You see the scale stays at the same level because both of the balls weigh the same."

"Let me give you one of these two balls that weigh the same. Now watch what I do with my ball." E then rolled his ball into a cylindrical shape four inches long. "Now, if I were to put both of our clay back on the scale, (E illustrated by pointing) is yours heavier, would yours make the scale go down? Or do they both still weigh the same, would the scale stay at the same level? Or is mine heavier, would mine make the scale go down?" After S responded, E asked, "Why is that?" "Now I have here two more balls of clay that weigh the same just like the first two. If I were to put them both on the scale, it would stay at the same level. (E pointed to illustrate.) Let me give you one and you watch closely what I do to mine." E then mashed his ball into a flat cake approximately three inches in diameter. "Now do they both still weigh the same, would the scale stay at the same level if I put them both on the scale? Or is yours heavier, would yours make the scale go down? Or is mine heavier, would mine make the scale go down?" And after

Appendix A (cont.)

S responded, "Why is that?" "Here are two more balls of clay that weigh the same. They would make the scale stay at the same level if I were to put them both on it. Okay, here's one for you. Now watch what I do to mine this time." E then cut his ball into halves. "Now is mine heavier, if I put them back on the scale, would mine make it go down? Or is yours heavier, would yours make the scale go down? Or do they both still weigh the same, would the scale stay at the same level?" After S responded, "Why is that?"

Conservation of Volume

"Now (First of all) I have here two jars of colored water." E placed two jars of colored water with graduated markings on the sides on the table. "If you look here you can see that the water in both jars comes up to about the same level, to this line here. Do you see that? Now I have here two lumps of clay." Two unequal lumps of clay were placed on the table. "One of these lumps takes up more room than the other one. Let me show you what I mean. Watch what happens when I put a lump in each of the jars. You see, the larger lump makes the water come up higher, way up above this line, while the smaller lump only makes the water come up to here. So the bigger lump takes more room, it makes the water come up higher. Alright, let me take these out and show you what happens when I put a ball into each jar. These two balls take up the same amount of room. You see they both make the water come up to the same level, right up to this line here. They both take up the same amount of room so they both make the water come up to the line."

Appendix A (cont.)

"Okay, now you take one of these two balls and watch what I do to mine." E then rolled his into a four-inch cylindrical shape. "Now, does yours take up more room; if I were to put these back in the jars, would yours make the water come up higher? Or do they still take up the same amount of room, would they both make the water come up to the same level, to this line here? Or does mine take up more room, would mine make the water come up higher?" After S responded, E asked "Why is that?" "I have here two more balls of clay that take up the same amount of room just like the other ones. If I were to put them into the jars they would both make the water come up to this line. Now you take one and watch closely what I do to mine." E then mashed his ball into a three-inch flat cake. "Now if I were to put the clay back into the jars, would they both make the water come up to the same level, do they both take up the same amount of room? Or does yours take up more room, would yours make it come up higher? Or does mine take up more room, would mine make it come up higher?" After S answered, "Why is that?" "And finally I have here two more balls that take up the same amount of room. If I were to put them both into the glass jars, they would both make the water come up to the same level, up to this line. Now I'll give you one and you watch closely what I do to mine this time." E then cut his ball into halves. "Now, does my clay take up more room; if I were to put them both in the jars, would mine make the water come up higher? Or does yours take up more room, would yours make the water come up higher? Or do they

Appendix A (cont.)

both still take up the same amount of room, would they both make the water come up to this line?" After S replied, E asked "Why is that?"

Appendix B

Raw Scores for Conservation Judgments and Explanations (in parentheses)

	Normals				Retardates			
	Mass	Weight	Volume	Totals	Mass	Weight	Volume	Totals
	3(3)	3(3)	3(3)		2(0)	1(0)	0(0)	
	3(1)	3(1)	1(0)		3(0)	3(1)	1(0)	
	3(3)	3(3)	1(0)		2(1)	1(1)	1(0)	
	3(3)	3(3)	3(3)		3(3)	1(1)	2(1)	
	3(3)	3(3)	2(2)		0(0)	0(0)	0(0)	
	3(3)	3(3)	3(3)		0(0)	0(0)	0(0)	
Low	2(2)	1(1)	0(0)		0(0)	0(0)	0(0)	
Mental	2(2)	3(1)	1(1)		0(0)	0(0)	0(0)	
Age	2(1)	0(0)	0(0)		2(1)	0(0)	1(0)	
Level	2(2)	0(0)	1(1)		2(0)	2(0)	0(0)	
	3(3)	3(3)	3(3)		0(0)	1(0)	0(0)	
	3(3)	3(3)	1(1)		1(0)	1(1)	0(0)	
	3(3)	3(3)	0(0)		2(1)	0(0)	1(0)	
	3(3)	3(3)	3(0)		0(0)	1(0)	0(0)	
	3(3)	0(0)	0(0)		0(0)	0(0)	1(0)	
Totals	41(38)	34(30)	22(17)	97(85)	17(6)	11(4)	7(1)	35(11)
	1(0)	3(3)	0(0)		3(3)	2(2)	0(0)	
	3(3)	3(3)	0(0)		2(2)	1(1)	0(0)	
	3(3)	3(3)	3(3)		1(0)	1(0)	1(0)	
	3(3)	1(1)	3(3)		2(1)	2(0)	2(0)	
	3(3)	3(3)	3(3)		2(2)	1(1)	2(2)	
	3(3)	3(1)	3(2)		3(2)	1(0)	1(0)	
High	3(3)	3(3)	3(3)		3(3)	0(0)	1(1)	
Mental	3(3)	3(3)	3(1)		3(3)	3(3)	3(3)	
Age	3(3)	1(1)	1(1)		2(1)	0(0)	0(0)	
Level	3(3)	3(3)	3(3)		3(3)	0(0)	0(0)	
	3(3)	3(2)	2(2)		2(2)	1(0)	1(0)	
	3(0)	2(2)	3(1)		3(3)	2(2)	0(0)	
	3(3)	3(3)	1(0)		3(2)	3(3)	3(3)	
	3(3)	3(3)	3(3)		1(1)	0(0)	0(0)	
	3(3)	2(2)	1(1)		1(1)	0(0)	1(1)	
Totals	43(39)	38(36)	32(26)	113(101)	34(30)	17(12)	15(10)	66(62)
Grand Total				210(186)				101(53)

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BIOGRAPHICAL SKETCH

James Frederick Brogle was born May 13, 1942, at Cincinnati, Ohio. He attended parochial schools in St. Petersburg, Florida, and was graduated from Bishop Barry High School in June of 1960. He received the Bachelor of Science degree with a major in Psychology from Xavier University in June, 1964. It was here that he was initiated into Psi Chi and Alpha Sigma Nu, both honorary fraternities.

In September of 1964, James Frederick Brogle enrolled in the Graduate School of the University of Florida, and received his Master of Arts with a major in Psychology in August, 1966. Since that time, he has pursued his work toward the degree Doctor of Philosophy. He completed his internship in clinical psychology at the J. Hillis Miller Health Center at Gainesville, Florida, in August of 1968. He is presently employed by the Psychological Services Center at the University of Notre Dame.

James Frederick was married to the former Barbara Ann Rehberg in July, 1966. They presently have two sons, Robert and Richard.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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