San Fernando Valley State College

A COMPARISON OF WECHSLER IQS AND PIAGET LEVELS IN CHILDREN

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Psychology

by

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ABSTRACT

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This study investigated the relationship between a conventional test of intelligence (the WISC), and a test of logical reasoning, as measured by Piaget's tests of conservation.

Briefly stated, the main hypotheses were:

(1) subjects functioning in superior IQ ranges would transcend their age-expected level on tests of conservation; and (2) a strong relationship would obtain between IQ scores and Piaget levels.

The subjects of this study consisted of 40 boys, 9 to 10 years of age, assigned to four groups of 10 each on the basis of the WISC, and representing the following IQ ranges: average, bright normal, superior, and very superior. All subjects were of the Jewish faith, from middle-upper class, who were receiving afternoon and weekend religious instruction.
Statistical analysis of the data revealed failure to confirm the first principal hypothesis; the second hypothesis, however, was partly confirmed. Moreover, confirmation of Piaget's contention of a sequential progression in the acquisition of notions of conservation (from substance through weight to volume) was obtained.

In general, although some communality was established between the Wechsler and Piaget (largely in terms of abstractive functions), the two measures appeared to be sufficiently independent to indicate the potential usefulness of the Piaget test as a supplementary tool in evaluating intellectual functioning. However, further investigation of the test seems needed to confirm its usefulness and increase its validity.
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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

In recent years there has been a growing dissatisfaction with the major role assigned the IQ as a criterion of intelligence (Bayley, 1949; Clarke and Clarke, 1953; Cronbach, 1960; Davis and Bells, 1956; Guertin, 1951; Honzik, MacFarlane and Allen, 1948; Hunt, 1961). Some of the sharpest criticisms of conventional tests of intelligence have been directed at their verbal loading, cultural (middle class) bias, and restricted range (Davis, 1948; Guilford, 1956; Haggard, 1954). Nor have so-called "culture-fair" (Davis and Bells) or "culture-free" (Cattell) tests succeeded in overcoming the main shortcomings attributed to traditional scales; together they suffer primarily from an overdependence on empirical considerations and from a lack of a theoretical foundation (Cronbach, 1960; Masland et al., 1958).

At the same time there has been insufficient recognition of the fact, that while middle class values
did account for the entrenchment of the IQ in our educational system, these values represent requirements of the dominant culture. Thus the IQ serves an important and useful function as an index of an individual's ability to meet these standards. For example, Anastasi (1958) has pointed out that they have proved to be of "considerable value as empirical instruments of prediction in a wide variety of practical situations. In forecasting academic promise, aiding in the selection of applicants for most jobs, and assisting the vocational counselor they are making a significant contribution" (p. 369).

It is not surprising that most objections to the utilization of the IQ as the sole criterion of intelligence have come from investigations in clinical areas, such as mental retardation and emotional disturbances. Indeed, so-called cases of functional mental retardation or pseudo-feeblemindedness (Clarke and Clarke, 1958, pp. 157-158; Guertin, 1949, 1950) are frequently cited in support of the need for alternative measures in evaluating mental and intellectual normalcy. Such measures would have to be reliable, relatively free from educational and cultural bias, and meaningful in terms of relevant and objective indices of intellectual ability and performance.
Jean Piaget's theoretical approach to intellectual functioning (1936, 1947, 1957) appears to offer a promising source for fulfilling the need for a new predictive and diagnostic tool. Equating intelligence with reasoning ability he has proposed a theory of cognitive development that unfolds in stages and can be tapped by means of various tests. At this point a brief review of Piaget's key concepts may prove clarifying.

The role of reasoning in mental development has been discussed by Piaget in terms of the bearing of reasoning ability to total intellectual functioning. According to Piaget's theory, intelligence involves the ability to perform various logical operations emerging at different developmental stages by a series of transitions from stage to stage. Beginning at birth, the course of intellectual development includes the stage of egocentrism in which logical operations are virtually absent (ages 4 to 6), the stage of concrete operations (ages 7 to 11), and the stage of formal reasoning (12 years and older). This course, moreover, underlies and parallels the progressive elaboration of what Piaget calls principles of conservation. These principles account for the acquisition of concepts like permanence, number, object, quantity, causality,
et cetera. Such concepts enable the growing child to come to terms with his environment and to orient himself in time and space.

According to Piaget, conservation may be regarded as an ideal state which is approximated as the end-result of intellectual growth. In other words, when achieved, conservation enables its possessor to retain an object as an idea when it is no longer physically present. It is the means by which one conserves space as a set of geometric relationships in the absence of immediate sensory cues. By its means one can also retain an impression of object constancy despite the visible disintegration or dissolution of an object. In this sense, conservation comprises all of those mental functions of mature intelligence which facilitate object constancy and individual stability in a world of change. As a process leading towards this final goal, conservation refers to the activity by which, at any stage in development, the individual keeps constant his relationship with the environment to the extent that his intellectual functions make this possible.

The following schema will serve to summarize what Piaget and Inhelder (1941) regard as the developmental sequence characterizing the child's
stages of progress with reference to the concept of conservation when dealing with physical dimensions such as size, weight, and volume.

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Levels of Conservation</th>
<th>Kind of Cognitions</th>
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<td>A. 4 to 6</td>
<td>No notion of conservation</td>
<td>Egocentric thinking—child is unable to conceive of perceptual world in terms of impersonal, abstract, reality-oriented concepts.</td>
</tr>
<tr>
<td>B. 7 to 8</td>
<td>Conservation of substance</td>
<td>Logical operations of class inclusion and of serial ordering, respectively. Child can take simultaneous cognizance of two (or more) variables, and he can order objects (or their properties) in series.</td>
</tr>
<tr>
<td>C. 9 to 10</td>
<td>Conservation of weight</td>
<td>Propositional operations—an internalized system of formal logic which enables deductive reasoning to be applied.</td>
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<tr>
<td>D. 11 to 12</td>
<td>Conservation of volume</td>
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Piaget does not deny individual differences with each stage of development. Such differences can be seen mostly in one child's ability to grasp at the outset the notions of conservation in contrast to the child whose understanding of such notions is hesitant, incorrect or dependent on corrective experiences. There may thus exist varying levels of mastery in
children within as well as between stages of conservation. For example, a child seven years of age may reveal lapses to pre-logical modes of reasoning although the general trend of his thinking already reveals the expected grasp of the age-appropriate level of conservation. In general such regressive (as well as progressive) patterns are more apt to appear in periods of transition, e.g. between stages.

Piaget has not indicated rigid points in the chronological development of the child when these levels of conservation appear. His total schema is not contingent upon the specific ages demonstrating the distinct levels, but rather upon the progressive and sequential unfolding of these stages. There is much evidence in support both of the concept of emergent logical operations as well as the assigned age of their emergence (Braine, 1959; Elkind, 1961; Inhelder, 1943; Lunzer, 1960). As a result, the ability to handle problems of conservation at given age levels can be used to estimate intellectual capacity or mental level.

**General Purpose of the Study**

The general purpose of this study was to examine the relationship between the Piaget levels of conservation and Wechsler IQs. Interest was focused on
the possibility of making predictions about performance from one test to the other. Since both tests measure intellectual functioning they would be expected to have certain cognitive elements in common; Cronbach (1960), in his brief reference to Piaget's work, indeed makes this kind of specific prediction. This study aimed at clarifying this relationship; in particular, since in Piaget's theory specific levels of cognitive development appear within defined age ranges, the present study sought to establish whether or not a high performance on the Wechsler (above normal) would be paralleled by a high performance on the Piaget, i.e. transcending the expected level for this age. Since, according to Piaget, the notions of conservation in their development appear to be relatively uninfluenced by academic and verbal experiences (Inhelder, 1943), it was also assumed that a stronger relationship would obtain between notions of conservation and the performance scale of the Wechsler, than between the former and the verbal scale.

This study thus represented a replication of Piaget's findings with respect to a particular stage of cognitive development; while at the same time relating them to another measure of cognitive functioning, the WISC. The particular age group
selected represented the age between 9 years 0 months to 10 years 4 months. While the method of selecting these subjects will be discussed later, it is pertinent to note that both technical and theoretical considerations were involved in this choice. From a technical standpoint this was an age range in which subjects would be readily available and expected to show high interest and motivation. Theoretically, not only would the basic proposition that this age group would achieve the level of conservation of weight be tested, but, by varying the sample along a continuum of IQ, allowance would be made for the possibility that some subjects (i.e. in the superior IQ ranges) would perform at the highest level of conservation.

**Hypotheses**

**Hypothesis 1.** A significant and positive correlation will be found between the WISC Full Scale IQ scores and the Piaget scores.

**Hypothesis 2.** A higher correlation will be found between Piaget scores and WISC Performance IQs than between Piaget scores and WISC Verbal IQs.

**Hypothesis 3.** Nine to ten year old subjects of the average and bright normal IQ ranges will demonstrate the acquisition of the understanding of the concepts of conservation of substance and weight, but
not of volume.

Hypothesis 4. Nine to ten year old subjects of the superior and very superior IQ ranges will demonstrate the acquisition of the level of volume in addition to those of substance and weight.
CHAPTER II

REVIEW OF THE LITERATURE

The IQ as a Criterion of Intelligence

Standardized tests of intelligence were originally developed in response to the need for selecting children who did not reach normal standards of educability. Yielding IQs of proven constancy and possessing a fair degree of predictive power (primarily in terms of school performance), these tests have been accepted as indispensable and have become highly cherished by school programs and educational systems in general (Budd, 1954; Stenquist and Lorge, 1951). Thus, because of our society's high evaluation of scholastic achievement, the related IQs have come to possess implications and expectations far transcending those ascribed to them in the standardization of the tests.

In recent years there has been increasing criticism of the use of the IQ as a criterion of intelligence. Cronbach (1960) noted that the available intelligence tests provide only an estimate of present
ability and not of intellectual capacity. Guertin (1951) and Davis and Eells (1956) concluded that a completely valid measurement of intelligence is impossible to achieve at the present time. The stability of the IQ over time, too, has been challenged by several authors (Clarke and Clarke, 1953; Hunt, 1961; Masland et al., 1958). Variations in IQ have been noted in observations on foster home children and in longitudinal studies such as the Berkeley Growth Study (Bayley, 1949) and the Berkeley Guidance Study (Honzik, Macfarlane and Allen, 1948). Such shifts (occurring more commonly in the lower age groups) were previously attributed to inherited patterns of mental growth and to errors of measurement (Goodenough and Maurer, 1942). More recent interpretations of the IQ changes, however, pointing out the apparent lack of a unitary genetic determinant, have emphasized instead the crucial role of experiential influences (Hunt, 1961; Masland et al., 1958).

Logical Thinking as a Measure of Intelligence: Piaget’s Developmental Theory

Modern discussions of the nature-nurture controversy take it for granted that cognitive efficiency involves both sets of factors.¹ It is now

¹See Appendix A on "Conceptions of Intelligence: A Historical Survey".
known that rate and level of intellectual development is influenced by the very young child's sensorimotor, affective and interpersonal experiences (Dennis, 1960; Goldfarb, 1943, 1959; Kirk, 1958). Timing is also important because of its relationship to maturation and other factors which determine readiness to profit by experience. For example, Wohlwill and Lowe (1962), investigating the concept of number discovered that training children under six in the solution of conservation problems produced only restricted, temporary, and non-generalizable gains. Ability to grasp the underlying principle is not manifest until a later age (Piaget and Inhelder, 1941).

The concept of developmental intelligence, as related to a child's present ability is not free from certain difficulties. For one thing, as a concept it fails to dispose of the problem of fluctuations in the rate of development, as would be supplied by normative data indicative of progress at different age levels. In addition, as shown by Hunt (1961), such developmental fluctuations run counter to the notion of the IQ's constancy. At best the concept in question may be said to equate intelligence with "problem-solving" ability.

Piaget's theory of intelligence (1936, 1941,
1947, 1953, 1955) appears to dispose of these difficulties. Rooted in biological principles it accounts for mental development in terms of an interaction between the organism and its environment as indicated in the following quotation:

Intelligence is an adaptation. In order to grasp its relation to life in general, it is therefore necessary to state precisely the relations that exist between the organism and the environment. Life is a continuous creation of increasingly complex forms and a progressive balancing of these forms with the environment (Piaget, 1936, p. 3).

A good part of the theory is devoted to showing the processes of transformation which account for a functional continuity between reflex behavior at birth and effective thinking and reasoning of the mature adult.  

A Brief Description of Piaget's Theory

The basis of the Piaget theory of intelligence is a genetic one (Piaget, 1955). Intelligent behavior is analyzed with respect to the growth continuum. His method is essentially empirical; constant problems or questions are presented to children of varying ages in samples large enough for general significance to be attributed to the differences found between age levels.

2See Appendix B on "The Development of Piaget's Theory: A Historical Survey".
Over 1500 subjects were tested for this theory. Over the series of Piaget's investigations which attack intelligence at different points on the growth continuum and focus on different functions, the over-all aim has been to trace the development of intelligence as it comes to deal with increasingly complex problems or as it deals with simple problems in increasingly more efficient ways.

The following are the four major stages of growth which have been delineated by Piaget:

1. The sensoriomotor stage. This period extends from birth to about two years (Piaget, 1945). Here the child learns to coordinate perceptual and motor functions and to utilize certain elementary schemata (a type of generalized behavior pattern or disposition) for dealing with external objects. He comes to know that objects exist even when outside his perceptual field and coordinates their parts into a whole recognizable from different perspectives. Elementary forms of symbolic behavior appear, as for example in the child who opens and shuts his own mouth while "thinking" about how he might extract a watch chain from a half-open matchbox. Expressive symbolism is also seen, as when Piaget's daughter at one year and three months lies down and pretends to go asleep.
laughing as she takes a corner of the tablecloth as a symbolic representation of a pillow (Piaget, 1945, p. 96).

2. The preoperational or representational stage. This extends from the beginnings of organized symbolic behavior—language in particular—until about six years (Piaget, 1955). The child comes to represent the external world through the medium of symbols, but he does so primarily by generalization from a motivational model—e.g., he believes that the sun moves because "God pushes it" and that the stars, like himself, have to go to bed. He is much less able to separate his own goals from the means of achieving them than the operational level child, and when he has to make corrections after his attempts to manipulate reality are met with frustration he does so by intuitive regulations rather than operations. (Roughly, these are after-the-fact corrections analogous to feedback mechanisms.) In the balance scale problem, preoperational subjects sometimes expect the scale to stay in position when they correct a disequilibrium by hand. They may, from an intuitive feeling for symmetry, add weight on the side where it lacks but may equally well add more on the overloaded side from a belief that more action leads automatically to success (Piaget, 1955, Chapter 11).
3. The stage of concrete operations. The child acquires the ability to carry out concrete operations between seven and eleven years. These greatly enlarge his ability to organize means independently of the direct impetus toward goal achievement; they are instruments for dealing with the properties of the immediately present object world.

4. The stage of formal or propositional operations. This is the final phase of growth preparatory to adult thinking and takes place between twelve and fifteen years. It involves the appearance of formal as opposed to concrete operations. Its most important features are the development of the ability to use hypothetical reasoning based on a logic of all possible combinations and to perform controlled experimentation. Both this stage and the stage of concrete operations are operational as distinguished from the first two. An operation is a type of action; it can be carried out either directly, in the manipulation of objects, or internally, when it is categories or (in the case of formal logic) propositions which are manipulated. Roughly, an operation is a means for mentally transforming data about the real world so that they can be organized and used selectively in the solution of problems. With the advent of operations, the margin of
trial-and-error is greatly decreased because the child selects means on the basis of an internal structure.

Piaget developed two concepts to define ideal states achieved by the individual by the end of his intellectual growth: conservation and reversibility. Both are defined as (a) final states of mental functioning which characterize mature intelligence; and (b) processes moving towards these goals.

**Conservation.** As an achieved goal (Wolff, 1960), conservation refers to those mental operations by which an individual retains the object as an idea when he no longer perceives the object as a concrete thing, or by which he conserves space as a set of geometric relationships independent of immediate sensorimotor cues, or by which he axiomatically accepts the mass constancy of an object although he sees it broken into pieces, flattened out, or dissolved in water. In this sense conservation comprises all those mental functions of mature intelligence which give rise to an awareness of the constancy between the individual and his environment. It is an ideal goal achieved by mature intellect. It is also the process of convergence on this final goal, and thus refers to the activity by which, at any stage in development, the individual keeps constant his relationship with the environment, to the
extent that his intellectual functions make this possible. Progress in conservation parallels the increasing complexity of sensorimotor schemata as well as the need to function deriving from them. At the beginning of intellectual development, the need is for circular repetition of reflex activity; at later stages, it will take the form of motivation to assimilate the object as a concrete entity which is now perceived as independent of action, and the child will conserve the object as well as its objective causal, spatial, and temporal properties by means of mental operations; but conservation does not reach this stable form until sensorimotor behavior has been internalized as thought processes, and until thought has become independent of immediate perception and motor actions.

**Reversibility.** Piaget defines reversibility as that capacity of mental functioning to achieve a final equilibrium "which insures a permanent possibility for returning to the starting point of the operation in question" (Piaget, 1947, p. 272). By this Piaget means that at the stage of formal operations (ages 12 to 15), the child's cognitive functions have advanced to the point where every direct act or thought will immediately evoke or imply all those mental operations by which the original action can be
cancelled or be compensated by a detour so as to arrive at the same end point. For example, to adult intelligence the direct act or thought of moving an object from point A to point B evokes in thought at the same time all those possible actions by which the displacement could be cancelled (moving the object back from B to A, for example), and all the equivalent actions which would compensate for the original displacement (for example, moving the object from A to C to D and then to B).

The significance of the reversibility of thought is that any new thought operation, or any new assimilated fact, no longer alters the mental structures referring to it nor the relation of all the mental structures to each other—i.e., the assimilation of novelties no longer introduces disequilibria, because thought is reversible and has available a compensatory thought which will restore the equilibrium. "Reversibility implies an equilibrium such that the structure of operational wholes is conserved while they assimilate new elements" (Piaget, 1947, p. 48).

This equilibrium will be achieved only after all sensorimotor activities have been internalized as thought patterns, and after these in turn have been freed from their dependence on perceptual cues and
sensorimotor activity. The tendency to reversibility runs exactly parallel with the tendency toward conservation: while reversibility refers to the increasing flexibility of the mental operations of intelligence which will maintain an equilibrium in the total organization of schemata, conservation refers to the activity of reversible mental operations which renders the apperception of the outside world constant and the mental structures flexible.

**The Development of the Conservation of Physical Quantities.** The course of intellectual growth described above underlies and parallels the progressive elaboration of principles of conservation of physical quantities. Piaget and his associates encountered a developmental sequence in the understanding of the conservation of the substance, of the weight, and of the volume of a physical body through the transformations of its shape. They found that these levels of understanding did not occur simultaneously, but followed each other in a sequential order as follows (Piaget and Inhelder, 1941):

1. Ages 4 to 6: No notion of conservation.  
   Egocentric thinking.  
   Perception dominates  
   logicality in behavior.
2. Ages 7 to 8: The conservation of substance is acquired.

3. Ages 9 to 10: The conservation of weight is acquired.

4. Ages 11 to 12: The conservation of volume is acquired and the stage of propositional operations is reached.

During the first stage, neither substance, weight nor volume are conceived as invariable by the child. During the second stage, substance is recognized as constant, but there is still non-conservation of weight and volume. During the third stage there is conservation of substance and weight, but non-conservation of volume. Finally, the fourth stage, is defined by the conservation of substance, weight, and volume.

Piaget found that the understanding of the conservation of each of these quantities implies the understanding of the conservation of the preceding quantity, while the inverse is not true. In the case of substance and weight the implication is very clear. Since the concept of substance is a direct continuation of the thing concept, the understanding of its conservation only supposes that the subject knows how to find again, after each transformation, all the parts
or particles of the substance. No consideration of the weight of the particles is necessary. The understanding of the conservation of substance on the other hand, is the basis for the discovery of the conservation of the weight. The subject attributes a constant weight to all the permanent particles and thus understands that their different arrangement does not affect the total weight of the body. It is the conception of these operations which leads the child to recognize the constancy of weight, a process which has to be achieved against the perceptual illusion of the changes in weight of a more expanded or a more contracted body. Similar relations of implications exist between the constancy of substance and weight on the one hand, and that of volume on the other hand. Thus the thing, its substance, weight, and volume, must be structured one after the other, each concept resting on the preceding ones (Aebli, 1950).

The Piaget Clay Test. Two quantities were formed whose equality the child admitted—two balls of modelling clay (Piaget and Inhelder, 1941). Then, while one ball remained untouched for purposes of comparison, the other ball was subjected to various transformations. It was either transformed into an elongated sausage, or sectioned into several pieces. After these transformations the questions were asked:
"Is there more or less clay in the sausage than in the ball? Does the sausage weigh the same as, more, or less than the ball? Does the sausage take the same as, more, or less space than the ball?" The volume was evaluated by immersing the body in a narrow container filled with water.

During the preoperational or representational stage described earlier, before seven years of age, the child believed that the three quantities changed with each transformation. Piaget and Inhelder reported that the children at this stage centered on only one dimension, one aspect of the transformed quantity. "There is more clay (it is heavier, it takes more space), because it is longer" and "there is less clay (it is lighter, takes less space), because it is thinner," are typical answers of this stage. In the case of the sectioning of the ball, the answers were exactly analogous: "There is more clay, et cetera, because there are more parts," and "there is less clay, et cetera, because the parts are smaller." The centration is either directed on the number of the parts or on the size of the parts.

As the child grew he arrived at the stage where he conceived the conservation of the substance, later of its weight and of its volume, as necessary outcomes,
of intelligible laws. It was not the identity of the body through all its transformations that caused this conviction. The young subjects who believed in the variability of the quantities knew as well that "we have not added anything nor taken away anything." It was the multiplication of the dimensions of the body and of the number and size of the fragments that was at the basis of the concept of conservation. The child became able to conceive of these two properties of the body at the same time, and therefore, saw that their product remained the same: the sausage-shaped ball was longer, but narrower than the ball, and there were more pieces of clay, but they were smaller. And again he invoked the reverse operation: the sausage can be modelled into a ball, the pieces can be joined again to make one body, therefore the quantity remains the same.

**The Piaget Sugar Test.** In another group of experiments Piaget and Inhelder (1941) reported on how the child attains the conservation of a body that is dissolved in water by the spontaneous construction of an atomistic explanation. To this end, one or two lumps of sugar were immersed in a narrow container of water. The child was asked to predict what happens to the sugar, whether it disappears entirely or will still
be there somehow; whether the increase of weight due to
the addition of sugar will remain after its dissolution;
and whether the level of the water that rises when the
sugar is added will go back to its original stage as the
sugar dissolves. They found that the stages of develop-
ment for these problems turned out to be exactly parallel
to those of the previously described developments.
There was a first stage during which the child believed
that the substance of the sugar was annihilated as it
dissolved (an immaterial taste was the only trace that
was believed to remain), that the vanishing substance
lost its weight, and that the level of the water also
came back to its original stage as the sugar dissolves.
The subsequent development was the same as in the case
of the modelling clay experiment. During the second
stage, there was conservation of substance, but non-
conservation of weight and volume; then conservation
of substance and weight, but not of volume; and
finally, in the fourth stage, conservation of all three
quantities.

These authors interpreted this development as
follows: The child constituted and founded a set of
operations in order to attain these constancies. He
projected the interiorized action of sectioning on the
phenomenon. As the sugar dissolved, he imagined that
the initial body was fractioned into smaller and smaller particles that finally could not be perceived anymore. But as they became smaller and smaller their number became increasingly larger in proportion. The multiplication of the two transformations entailed an invariant product. This operation of sectioning is reversible: "If one takes all (the little pieces) that makes the big lump again," said a subject of 10 years 11 months (Piaget and Inhelder, 1941, p. 128).

The Piaget Bars-Cylinders Test. With their bars-cylinders test Piaget and Inhelder (1941) took the three conservation problems into the realm of formal propositions. In the first developmental stage, the child yields to the perceptual illusion in which obliquely placed bars seem different in weight because of the illusion of size differences, or because of the different colors, and fails to draw the conclusion of A=C if A=B and B=C. During the second stage, conservation of substance is achieved. The child considers the homogeneous elements (the colored bars) as containing the same amount of matter and draws the correct conclusion of equality. The perceptual illusion (contained, for instance, in the placement of the bars) is thus overcome through reversibility: for example, the child can mentally (or in reality) place the bars
alongside each other or superimpose one upon the other to correct the perceptual distortion and substitute logical equivalence for it. However, the child, during the second stage, cannot effect simple nor additive compositions between heterogeneous elements; this is achieved during the third stage when weight as a pure, objective quality is abstracted and thought of as a physical invariant. The child is now able to execute any logical compositions involving pure weight. For instance, he will conclude that if a piece of wax and a piece of lead each equals a bar, then they equal each other; he will also reason that the addition of an equal element to each side of the equation will not disrupt the equivalence—as is the case with a child in the earlier stages. Again, the reversibility of the operation is conceived: the two added elements can be taken away and the original equation remains the same. For the conservation of volume problems, the equivalence problems with the cylinders (as well as heterogeneous elements) are introduced. Lack of conservation of volume is apparent through the first three developmental stages, during which the performance of the child is characterized chiefly by inability to disassociate weight from volume.

Thus, during the intuitive stage the child
anticipates that variation in the position of the cylinder will affect the height of the raised water level (because of imagined changes in weight and pressure) and cannot adapt himself to the experimental facts in order to explain them. During the first concrete stage, the equivalence of homogeneous cylinders, as well as cylinders of similar shape but different weight, is acknowledged, the child appearing to dissociate weight from "size." However, similarly to the homogeneous bars, the seeming conservation of volume is in fact due to the child's attributing similar quantity to the cylinders and coordinating this quantity (as "size") with volume; when heterogeneous elements (differing in shape) are presented to him, the child can no longer compose the volume equivalence. During the third (or second "concrete") stage, there is an inductive recognition (on the basis of experimental verification) that the equivalence of displacement is not due to weight or size, and that there must be other factors involved in bringing about this equality; the child may even—in the course of the verification trials—elaborate the relationship between the volume of the immersed object and the level of the displaced water. However, it is not until the "propositional" stage that the child deduces, at the
outset, the general law of the displacement of the volume of water. Now the child understands that a lead cylinder, having the same dimensions as a lighter cylinder, will displace the same amount of water regardless of its position. Reversibility in thinking again enables him to construct the invariance of volume when shown a small ball of clay and a metal cylinder, each displacing the same amount of water: he discovers that the clay could be shaped into a cylinder having the same dimensions as the other cylinder, and that the amount of water displaced would fill a cylindrical container of the same size as the metal cylinder. In both instances, a coordination of relations involving multiplicative compensation of three dimensions is conceived as the only important factor, and one that always yields an invariant product. Thus, the child's intellectual achievement in the fourth (or third "concrete") stage implies firstly, a dissociation or abstraction of the spatial dimensions of the object from the weight (and the force that it exerts); secondly, coordination of relations (operation of proportionality) permitting recognition of the invariance of the object's volume as a function of its dimensions, and its correspondence with the volume of the displaced water; and, thirdly, an ensemble of
logical and experimental invariants (reversible operations).

The above analysis illustrates Piaget's use of the algebra of logic to describe and explain thought in terms of its logical properties. Still absent in the intuitive stage these properties manifest themselves in the concrete stage, as logical operations with which the child can classify, order serially, form equalities or set up correspondences between objects. In the formal stage, these operations are combined into a "structured whole" to constitute a purely formal logic, concerned with propositions as well as with object, with proportions (probabilities, correlations, multiplicative compensations, et cetera) and with combinatorial operations (combinations, permutations, et cetera). The adolescent, instead of coordinating facts about the actual world, can now deduce hypothetical or potential relationships among variables which can be verified by experiment as well as invariants which fall outside the range of empirical verification. Obviously, this does not mean that the child acquires class logic or propositional logic in a formal sense, but rather that the child's solutions to problems imply the presence of certain logical forms. More importantly, it indicates that, while the number of intelligent acts that a child
can perform at any age depends on his learning experiences and on situational variables, their range is limited to the logical operations available to him.

The child's reasoning abilities thus develop through four main transitional stages which characterize and correspond to, respectively, the thought processes of the pre-school, school child, preadolescent and adolescent. Each stage represents a point of integration (or "grouping") of the child's experiences and knowledge into concrete and logical levels. The successive integrations or logical groupings thus represent basic mental structures which underlie and mediate the child's approach to everyday problems and situations. Inhelder (1943), in discussing the various factors affecting people's reactions to the Piaget tests, as well as various test behavior manifestations, states:

> If we nevertheless obtain in the face of this diversity of conduct a common mode of reasoning, then it is our choice of tests, no less than of method, which permits us to isolate the functional nucleus of thought from the array of other mental manifestations. The conservation problems highlight the functioning of intelligence independently of contingencies deriving from the verbal and memory acquisitions or in particular from scholastic training (p. 266).

**Investigations of Piaget's Theory of Intelligence**

The large number of studies devoted in recent years to a direct investigation of Piaget's central
theoretical propositions serve to highlight the relative lack of interest in, and the dearth of studies based on Piaget's work in previous years. Parsons (1960) has singled out Piaget's lack of methodological rigor, his philosophical orientation, and his nonmotivational emphasis as the main factors accounting for the lack of interest shown by American psychologists in his contributions. His use of formal logic to explain intellectual functioning, his style of writing, and (until recently) the small number of his works translated into English, probably also account for this neglect.

Studies on the stages leading to and order of conservation of substance, weight and quantity, have in general confirmed Piaget's own findings (Dodwell, 1960; Elkind, 1961; Hyde, 1959; Lovell and Ogilvie, 1960; Peel, 1959; Pinard, 1959; Smedslund, 1959, 1961; Slater, 1958; Vinh-Bang, 1959). Lovell and Ogilvie (1960) indicate that conservation of substance, when first attained, may be tied to specific materials. They found that some children who exhibited non-conservation in the clay experiment nevertheless showed conservation when a rubber band was stretched and they were asked if it contained the same amount of rubber in this condition as before. Analogously, Beard (1957) and Hyde (1959) found that some children who showed
nonconservation in the clay experiment nevertheless exhibited conservation when the same type of experiment was carried out with liquids. Differential experience with particular kinds of materials, therefore, may be influential in the initial occurrence of matter conservation. Put another way, such conservation does not necessarily emerge full blown immediately but, rather, may at first be limited to certain familiar materials and only later increase its generality.

Wallach (1963) poses the question whether volume conservation is more difficult to attain than substance and weight partly because of the type of test predictions of water displacement which are customarily used by Piaget and his associates. Lunzer (1960) and Lovell (1961) point out that comparison of water displacements is a relatively rare happening in the child's experiences and also requires the prior recognition that the volume of the displaced water is conserved. Wallach further indicates that the greater difficulty of volume conservation may result in part from the view, frequently found in the child's first atomic-particle conception and certainly understandable in terms of some of his experiences, that each particle of matter will expand or be compressed depending on its spatial location and, hence, on how many other particles are
pressing down upon it.

Hyde (1959) and Slater (1958) have demonstrated a relationship between experiential factors and the rate at which concepts of conservation develop. Such relationships appear to be, however, limited to the "match" between the child's existing schemata and the encountered experiences (Gouystard, 1959; Matalon, 1959; Smedslund, 1961). Smedslund (1961) compared children who had already exhibited conservation of weight in a pretest with clay objects and children who had failed to demonstrate it in the pretest but had subsequently been instructed in the concept by means of training in which the child's predictions about the weights of standard and deformed objects were checked each time on a scale. Such training was continued to the point where the latter group showed conservation with explanations which were indistinguishable from those of the former group. When an attempt was made to extinguish such conservation by comparing the weights of standard and deformed objects after a subterfuge had left the former heavier than the latter, all who had learned conservation during the experimental training lapsed back into nonconservation explanations. On the other hand, about half of those who had shown conservation in the pretest resisted the attempted extinction, searching for
conservation-consistent interpretations such as, "We must have lost some clay on the floor." This evidence suggests that, once acquired, the conservation of weight is difficult to extinguish. A superficially similar concept acquired through a controlled but limited training regimen is not equivalent.

Smedslund (1961) also tried in another study to discourage the use of perceived largeness as a presumably veridical cue to heaviness by means of training in which, for example, the larger of two objects was demonstrated to be much lighter than the smaller, and objects equal in size and the same in shape were demonstrated to be very much different in weight. Such attempts did not succeed in hastening children's acquisition of weight conservation across shape changes. They still responded without conservation and continued to explain their judgments of weight differences in terms of the view that largeness is a veridical cue to greater weight.

These experiments suggest that it is difficult to facilitate the acquisition of weight conservation with training that demonstrates the irrelevance of shape and size to weight. Wallach (1963) concludes that the effectiveness of a given type or amount of experience is relative to the conceptual attainments already at
the child's disposal--a "discontinuity" theory of the effects of experience. This is consistent both with Piaget (1941) and Inhelder's (1944, 1953) findings and theoretical emphasis on the continuous, gradual and non-regular epigenesis of the structures of behavior and thought. This point appears to have been missed in some studies examining Piaget's developmental stages (Braine, 1959; Estes, 1956; Feigenbaum, 1961; Yost, Siegel and McMichael, 1961). It also underlies the problem of cultural bias suggested by some in Piaget's theory (Dennis, 1960; Kessen, 1960; McCarthy, 1930). As Wolff (1960) has pointed out, a contention of cultural differences requires a demonstration that the sequence of stages and mechanisms of transition from one to another (and not just the periods of transition) differ from culture to culture. That Piaget is not unaware of cultural factors is indicated by the following excerpt (Piaget, 1937, p. 216):

The age of about 11-12 years, which in our society we found to mark the beginning of formal thinking, must be extremely relative, since the logic of the so-called primitive societies appears to be without such structures. Moreover, the history of formal structures is linked to the evolution of culture.

On the theoretical level, the factor analysis of the Interage Correlations of the Berkeley Growth Study (Bayley, 1949) yielded results consonant with
Piaget's formulation. Three factors were found corresponding to Piaget's first three types of intellectual functioning, and closely approximating them in periods of emergence. While Piaget's fourth period of transition (11 to 12 years of age) did not turn up, Garrett's (1946) earlier finding that the special verbal and numerical factors become more distinct with increasing age suggests that there may be qualitative changes in intellectual performance at this time. Moore (1929), moreover, found that children under 11 years of age were generally unsuccessful on tests demanding inferences from propositions.

Also on the theoretical level, Piaget's formulation is consistent and compatible with Werner's (1957) comparative theory of development based on cross-cultural and cross-species investigations. Furthermore, Piaget's genetic assumptions and developmental stages correspond closely to those of the psychoanalytic theory of development (Wolff, 1960); in particular the theoretical dichotomization in psychoanalysis between the "primary processes" of infancy and early childhood and the "secondary processes" developing out of the resolution of the Oedipus complex implies both a transition in intellectual development while the age periods correspond, respectively, to Piaget's first and
last two phases of development.

On the dissonant side, questions of a serious nature were directed at some of the implications of Piaget's theory. Kessen (1960) wondered about a possible artefact in the central role assigned conservation and reversibility due to Piaget's choice of physical properties of objects. He also raised the issue of the relationship between certain language characteristics and the acquisition of reversibility. The role of verbal behavior and particularly the difficulties inherent in Piaget's verbal interrogation approach were carefully analyzed by Berko and Brown (1960). Finally, Hunt (1961), who has most persuasively shown the implications of Piaget's formulations for different disciplines, also asked of what consist individual differences when adults (or children) share the same groups of logical operations. To these questions one may add those pertaining to the role of experiences past the period (adolescence) in which intellectual development normally attains maturity.

Piaget's results have also been criticized on methodological grounds (Berko and Brown, 1960; Deutsche, 1943; Dodwell, 1960; Huang, 1943; Kentler, 1950; Nass, 1956). Many of these criticisms are pertinent (for example, Piaget's failure sometimes to
explain his procedure, specify the selection of samples, et cetera) and some have even been recognized by Piaget (1953). On the other hand, many of the charges actually reveal a confusion of Piaget's empirical observations with the lack of statistical elegance in his method of presentation, thus raising pseudo-problems rather than valid criticisms (Hunt, 1961). Departures and omissions from Piaget's methods and procedures can be found in studies which purport to be replications of Piaget's tests of conservation (Elkind, 1961; Feigenbaum, 1963) casting doubt on the validity of the results, at least with respect to their relevance to Piaget's theory.

Perhaps the value of the present study lay not only in its attempt to relate Piaget's tests of conservation to another measure of cognitive functioning, but also to its utilization of the tests of conservation in an objective fashion and in strict accordance with Piaget's own approach. Three successive tests were used to insure the reliability of the data and to determine if the sequential development of notions of conservation reported by Piaget was valid for the sample.

3The more recent Geneva research (1959) seems to have yielded to the Anglo-Saxon custom of specifying the number of subjects on which generalizations are based. We learn that over 2,000 children, for example, constitute the sample.
A crucial aspect of Piaget's method (which was ignored in the studies cited above) was carefully maintained; namely, that children who do not spontaneously demonstrate the possession of notions of conservation may nevertheless adapt their responses in the face of corrective experience. The utilization of the three Piaget tests in comparison with Wechsler scores was carried out primarily for the purposes of investigating the following predictions:

1. An expectation of a strong association between the WISC and the Piaget tests;
2. An expectation that the Piaget tests will be more strongly associated with the Performance subtests of the WISC than with the Verbal subtests;
3. An expectation that nine to ten year old subjects of the average and bright normal IQ ranges will demonstrate the acquisition of the understanding of the concepts of conservation of substance and weight, but not of volume.
4. The expectation that nine to ten year old subjects of the superior and very superior IQ ranges will demonstrate the acquisition of the level of volume in addition to those of substance and weight.
Subjects

The subjects of this study consisted of 40 boys representing four groups of 10 subjects each, and representing four levels of intelligence according to the following Wechsler intelligence classification (Wechsler, 1941):

<table>
<thead>
<tr>
<th>IQ LIMITS</th>
<th>CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 - 109</td>
<td>Average</td>
</tr>
<tr>
<td>110 - 119</td>
<td>Bright Normal</td>
</tr>
<tr>
<td>120 - 129</td>
<td>Superior</td>
</tr>
<tr>
<td>130 &amp; over</td>
<td>Very Superior</td>
</tr>
</tbody>
</table>

Subjects for each of the IQ ranges were selected on the basis of the following four WISC sub-tests: vocabulary, information, comprehension and arithmetic. The age range of the subjects was 9 years 0 months to 10 years 4 months with a mean age of 9 years 9.1 months.

The subjects also met the following additional criteria: (a) absence of known gross emotional, physical
or neurological disorders; (b) absence of language handicaps; (c) normal school grade achievement, each subject attending the appropriate grade for his age; (d) resident of West Los Angeles; (e) member of middle to upper class family; (f) American-born Caucasian of the Jewish faith; (g) private parochial school attendance twice a week.

The subjects all came from a social environment and ethnic group which value highly scholastic performance and intellectual achievement. Both at home and school moderate pressures are maintained to achieve high standards of academic work. Rather than have adverse influences, the fact that these children attend a private parochial school actually enhances their scholastic motivation and efficiency.

Although the testing was accomplished on Saturday or Sunday afternoon and encroached upon their leisure time, the cooperation of both the parents and the children was easily obtained. The children demonstrated genuine pleasure at having been chosen for the project. The parents were also well-motivated.

The research was explained to them as follows:

I should like to invite your child to participate in a research project which is designed to evaluate the usefulness of a new test of reasoning abilities for children. While no significance will be attached to any individual child's performance,
the results of testing a large group of students will further our understanding of the usefulness of such tests.

Test Materials

The test materials consisted of the following:

A. The Wechsler Intelligence Scale For Children

1. Verbal Tests
   a. General Information
   b. General Comprehension
   c. Arithmetic
   d. Similarities
   e. Vocabulary

2. Performance Tests
   a. Picture Completion
   b. Picture Arrangement
   c. Block Design
   d. Object Assembly
   e. Coding

B. The Piaget Tests of Conservation of Physical Quantities

1. A center-tower two-platform scale which balanced itself instantly, and had an indicator showing equality or non-equality of objects on the plates.

2. Two glass beakers of 600 milliliter capacity, 3/4 filled with water.
3. Silicon putty weighing about 8 ounces.

4. Two graduated glass cylinders of 50 milliliter capacity, 1/2 filled with water.

5. Large sugar tablets.

6. A piece of metal, smaller in volume but heavier than a sugar cube.

7. Three plain-colored aluminum bars, 6 inches by 1 inch by 1/4 inch, weighing 2 ounces each.

8. Four colored steel bars, blue, yellow, red and black, having the same dimensions as the plain-colored bars, but weighing 6 1/2 ounces each.


10. A flat round piece of lead weighing 6 1/2 ounces.

11. A cylindrical piece of modeling clay weighing 6 1/2 ounces.

12. Three metal cylinders, one red, one yellow and one black, 1 3/4 inches high and 7/8 inches in diameter, and weighing 1 1/2 ounces each.

13. Three identical-appearing metal cylinders of the same dimensions as the colored cylinders, but weighing respectively 1 1/2, 1 3/4 and 2 ounces.

14. A metal cylinder twice the height of a small cylinder, measuring 3 1/2 inches by 7/8 inches and weighing 3 ounces.
15. A metal cylinder triple the height of a small cylinder, measuring 5 1/4 inches by 7/8 inches, and weighing 4 1/2 ounces.

16. A clay ball displacing the same amount of water as a small cylinder.

17. A piece of wax displacing the same amount of water as a small cylinder.

18. A Stenorette tape and sound recorder.

Procedure

The Wechsler Intelligence Scale for Children was first administered to each subject. Following a 15 minute recess during which the subject was served refreshments and engaged in light conversation, the Piaget Tests were administered. Here the research procedure involved an essentially directive but supportive situation in which each subject was seen individually and under conditions of free conversation for approximately an hour.

After ascertaining that the use of the two-platform scale was clear to the subject, he was interviewed concerning his grasp of the principles of conservation of substance, weight and volume. The inquiry aimed at revealing first the notions and beliefs underlying the subject's verbal responses to problems of conservation, and secondly, at establishing his ability
to adapt his thinking to objective facts. The following are the three Piaget tests administered:¹

1. The Clay Test. Each subject was first shown two identical clay balls and invited to verify their weight equality on the scale. He then flattened one of them into the shape of a pancake and was asked: "If you were to put these back on the scale, would the thin pancake weigh as much as the clay ball, or more, or less?" Whatever his answer, the subject was asked to explain it. In the case of a correct response, the examiner asked if it did not matter, for example, that the pancake was now thin and flat as against the round, solid ball. If the subject gave a satisfactory answer, he was then asked to make the pancake into the shape of a hot dog, and the inquiry proceeded as described above. Correct solution of the weight problem on the hot dog shaped clay was followed by a third and final deformation, this time breaking the "experimental" clay into many small pieces. As long as the subject continued to perform adequately, no verification of his responses was carried out. The deformed clay was not weighed against the comparison clay ball on the scale. Instead, the inquiry proceeded to probe

¹See Appendix C for outline of questions used by examiner in administering Piaget tests.
the subject's understanding of the conservation of volume. On the other hand, if the subject failed the weight problem (in any deformation) he was asked, first, if he could roll the pancake (or the hot dog, et cetera) back into the shape of a ball, and, second, how it would be then if weighed with the comparison ball. If the subject now still believed that the pancake (or the hot dog, et cetera) still weighed less than the clay ball, the inquiry proceeded on the level of substance and the subject was asked: "Is there as much clay in the pancake as in the clay ball, or more, or less?" Regardless of his answer, the subject was invited to compare the pancake with the clay ball on the scale and asked to explain their weight equality in view of his previous anticipation of inequality. If the subject was able at this point to change his prior explanation in favor of an adequate one, the testing proceeded with the next deformation. Failure to generalize from such an instance of experimental verification, that is, wrong explanation on subsequent deformations, was regarded as an indication of failure at the level required. The inquiry proceeded now to the next level of conservation, in this instance that of volume. To test for conservation of volume, the conversation was directed to the relationship between the water level in
the glass beaker and a clay ball immersed in the water. The present water level was indicated with a red mark, as was the displaced level. The subject was then asked to flatten the other clay ball into a pancake and asked: "Will the pancake make the water go up as much as the clay ball, or more, or less?" Again correct as well as false notions were inquired into for the underlying reasons and beliefs. In the case of correct answers, the inquiry proceeded with the subsequent clay deformations. With wrong responses, a verification of the equality of displacement was carried out and the subject's reactions to it elicited. Conservation of volume problems involving other deformations were then presented to the subject to note whether he persisted in his belief of lack of conservation, or if he was able to generalize from the first corrective experience.

2. The "Sugar-Dissolution" Test. This test was presented immediately following the clay test. Each subject was presented with two graduated glass cylinders half filled with water and asked to ascertain their weight equality on the scale. He was then shown a lump of sugar and asked questions regarding the three levels of conservation. These questions followed the sequence of substance, weight and volume. For conservation of substance the subject was asked what would happen to the
sugar when immersed in the water; where it would be once dissolved; how one could know that it was still in the water if it could not be seen, et cetera. For conservation of weight, the subject was asked if the cylinder containing the sugar would continue to weigh more than the comparison cylinder; if there would be a weight equality upon complete dissolution of the sugar or any weight fluctuation due to the dissolution of the sugar, et cetera. For conservation of volume, the subject was asked if the sugar would displace water; if the displaced level would remain raised or change following the complete dissolution of the sugar; if a piece of lead, smaller but weighing more than the sugar, would displace as much water as the sugar or not, et cetera. While closely following the subject's responses, the inquiry always sought to determine his underlying notions and reasoning. Following the discussion and inquiry, the verification procedure was carried out for false notions and the subject's reactions to the new facts obtained.

3. The Bars-Cylinders Test. This test, administered following the sugar test, probed the subject's ability to deduce the following:

I. Weight equivalence

A. Homogeneous elements

1. Simple equivalence
a. Plain colored bars (for example, could the subject, having verified that Bar A = Bar B, and Bar B = Bar C, deduce that Bar A = Bar C?).  
b. Differently colored bars (if red = black, and yellow = black, then is red = to yellow?). The bars were placed obliquely (to induce perceptual illusion of size differences) and/or in different positions (such as one bar lying flat while the other is standing on its end—this in order to induce a weight-difference illusion).

2. Additive equivalences
   
   If blue = black, then do blue + black = red + yellow?

B. Heterogeneous elements

1. Simple equivalences
   
   Objects differing in shape, size and color (for example, if a piece of wax and a piece of lead each equal a colored bar, will they equal each other?).
2. Additive equivalences

Similarly, two colored bars versus the wax and the lead; the lead + a bar + the cylindrical clay versus two bars + wax, et cetera. Experimental verifications were carried out after false deductions and the inquiry then proceeded with the next problem.

II. Volume equivalence

A. Homogeneous elements

1. Simple equivalences of cylinders of the same shape and weight, but of different colors. For example, could the subject, having verified that cylinder A (yellow) = cylinder B (black) in displacement of water and that cylinder B = cylinder C (red), deduce that A = C (A standing upright and C placed horizontally)?

2. Additive equivalences of cylinders of the same shape and weight. Cylinders A + B (placed horizontally) versus a tall cylinder double the
size of each (standing upright),
et cetera.

3. Simple equivalences of cylinders of the same shape but of different weight. Each subject was asked to verify the weight difference between the two cylinders and then to predict the water displacement of the heavier cylinder in comparison to the control cylinder.

4. Additive equivalences of cylinders of the same shape, but of different weight. The subject was also asked to make predictions about water displacement when comparisons between more than three cylinders as well as between tall and small cylinders are involved—the weights and positions always varying and only the volume held equivalent.

B. Heterogeneous elements

1. Simple equivalences

Objects differing in matter, shape and weight. The subject was shown a metal cylinder and
a ball of clay, and invited to ascertain their weight difference on the scale. He was then shown that they each displace the same amount of water and asked to explain the reason for this. Other heterogeneous objects were likewise introduced, such as a piece of wax.

2. Additive equivalences

Two heterogeneous cylinders in different positions versus a cylinder and a clay ball.

Scoring Method For The Piaget Tests

A study of Piaget test protocols has shown three main types of performance: (a) performance characterized by a lack of notions of conservation, associated with inability to profit from the experimental verification in order to modify or change the previous false notions; (b) performance in which a convincing demonstration of possession of notions of conservation was spontaneously given; (c) performance characterized by initial failure to solve the problems of conservation, but with a demonstrated capacity to
modify the first response in the light of the experimental facts, as well as to generalize the corrected notions to other, similar problems of conservation. Accordingly, three different scores were chosen, as follows: 0 for complete failure; a score of 2 for a correct response spontaneously given; and a score of 1 for a correctly modified response. In addition, in order to account for the sequential progression in the acquisition of notions of conservation (from substance through weight to volume), it was decided to rank the scores, assigning scores of 1 and 2 to substance, 3 and 4 to weight, and 5, 6, 7 and 8 to volume. Piaget refers to two distinct levels of performance on conservation of volume on the bars-cylinders test; namely, volume equivalence of homogeneous objects (same shape but different weight) scored 0, 5 or 6, and volume equivalence of heterogeneous objects (different material, shape and weight) scored 0, 7 or 8. In this way, a range of scores from 0 to 8 became available for scoring the performance on the Piaget tests. A score of 0 always indicated failure of conservation; even-numbered scores reflected success at the spontaneous level; and odd-numbered scores indicated successfully modified responses. The score for the highest level achieved on each subtest was considered the subject's subtest score.
The scoring system may be diagrammed as follows:²

\[
\begin{array}{cccccccc}
S & S_a & S_b & W & W_a & W_b & V & V_a & V_b & V_c & V_d \\
\text{Clay} & 0 & 1 & 2 & 0 & 3 & 4 & 0 & 5 & 6 & \\
\text{Sugar} & 0 & 1 & 2 & 0 & 3 & 4 & 0 & 5 & 6 & \\
\text{Bars-Cylinders} & 0 & 1 & 2 & 0 & 3 & 4 & 0 & 5 & 6 & 0 & 7 & 8
\end{array}
\]

The highest subtest score represented the highest level of achievement for each subject and was used as the raw score for statistical analysis. In order to prove the stability of this procedure, an intercorrelation of the subtests was undertaken. All interviews were tape-recorded and transcribed. To insure reliability of the scores assigned to each subject, an additional scorer, a psychologist, scored the data.

**Statistical Design**³

1. The Pearson product-moment coefficient of correlation was used to measure the relationship between the scores assigned each of the subjects by the two independent scorers. This was done to determine the reliability of the scores assigned.

²See Appendix D for a copy of the score sheet used for each subject.

³The data of this study was analyzed through the Research Department of the Pacific State Hospital.
2. The Kuder-Richardson formula for estimating overall reliability was utilized to determine the internal consistency of the Piaget tests.

3. A correlational matrix using all WISC and Piaget scores was employed to determine the following:
   a. The correlations among the Piaget subtests.
   b. The correlation between the WISC Full Scale IQ scores and the Piaget scores.
   c. The correlation between the WISC Performance Scale IQs and the Piaget scores; and between the WISC Verbal Scale IQs and the Piaget scores.

4. For purposes of interpretation and evaluation it was decided to establish a requirement for confirmation of hypotheses at .05 (or higher) level of significance.
CHAPTER IV

RESULTS

The raw data of this study consisted of the following: each subject's scores on the three tests of conservation, the highest score representing the measure of highest achievement on this test; and his WISC Full Scale, Verbal Scale, and Performance Scale IQs, including all subtest scores. The range of the Piaget scores for the entire sample was 3 to 8, while the IQ ranged between 99 to 143.

WISC scores for each member of the four IQ groups are given in Table 1. This table includes the ranges, means, and standard deviations for each group. Piaget scores for each member of the four IQ groups, as well as means and standard deviations for each of these groups, are reported in Table 2. The means and standard deviations for the WISC and Piaget scores for the entire sample are shown in Table 3. The inter-correlations of Piaget scores and WISC IQs are given in Table 4.

The following inter-rater reliabilities were obtained for the Piaget tests: highest (raw) scores,
### TABLE 1

**WISC Scores for the Four IQ Groups**

**Average IQ (99-108)**

<table>
<thead>
<tr>
<th>Subj No.</th>
<th>Full ScIQ</th>
<th>Verbal ScIQ</th>
<th>Perceptual ScIQ</th>
<th><strong>Verbal Subtests</strong></th>
<th><strong>Performance Subtests</strong></th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Info</td>
<td>Comp</td>
</tr>
<tr>
<td>1</td>
<td>108</td>
<td>105</td>
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(Very Superior IQ (130-143))

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# TABLE 2

## PIAGET SCORES FOR THE FOUR IQ GROUPS

### AVERAGE IQ

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**Means** 115.90 4.10 3.00 3.60 3.90  
**S.D.** 4.61 1.37 0.00 .67 1.44

### Bright Normal IQ

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### TABLE 2—(Continued)

#### Superior IQ

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MEANS AND STANDARD DEVIATIONS FOR THE WISC AND PIAGET SCORES
FOR THE ENTIRE SAMPLE

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<td>115.1</td>
</tr>
<tr>
<td>S.D.</td>
<td>12.8</td>
<td>13.66</td>
<td>11.02</td>
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<table>
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<tr>
<th>WISC VERBAL SUBTESTS</th>
<th>Inform</th>
<th>Compre</th>
<th>Arithm</th>
<th>Simila</th>
<th>Vocabu</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.D.</td>
<td>3.29</td>
<td>3.61</td>
<td>2.24</td>
<td>3.31</td>
<td>2.74</td>
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</table>

<table>
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<th>WISC PERFORMANCE SUBTESTS</th>
<th>Pi Com</th>
<th>Pi Arr</th>
<th>Bl Des</th>
<th>Obj As</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>11.87</td>
<td>11.22</td>
<td>12.42</td>
<td>11.72</td>
<td>13.60</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.94</td>
<td>2.75</td>
<td>2.18</td>
<td>2.30</td>
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<table>
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<tr>
<th>PIAGET PERFORMANCE</th>
<th>Raw Score</th>
<th>Clay Test</th>
<th>Sugar Test</th>
<th>Bars-Cyl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Means</td>
<td>4.42</td>
<td>3.35</td>
<td>3.87</td>
<td>4.30</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.31</td>
<td>.57</td>
<td>.68</td>
<td>1.39</td>
</tr>
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### TABLE 4
CORRELATIONS BETWEEN PIAGET SCORES AND WISC IQs

<table>
<thead>
<tr>
<th>WISC Scores</th>
<th>Piaget Scr</th>
<th>Clay Test</th>
<th>Sugar Test</th>
<th>Bars-Cylinders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
<td>$P$</td>
<td>$r$</td>
<td>$P$</td>
</tr>
<tr>
<td>Full Scale IQ</td>
<td>.141</td>
<td>.374 &lt; 0.05</td>
<td>.305</td>
<td>.171</td>
</tr>
<tr>
<td>Verbal Scale IQ</td>
<td>.020</td>
<td>.290</td>
<td>.225</td>
<td>.037</td>
</tr>
<tr>
<td>Performance Scale IQ</td>
<td>.272</td>
<td>.391 &lt; 0.05</td>
<td>.333 &lt; 0.05</td>
<td>.308</td>
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<tr>
<td><strong>Verbal Subtests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Information</td>
<td>.037</td>
<td>.179</td>
<td>.259</td>
<td>.051</td>
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<tr>
<td>Comprehension</td>
<td>-.090</td>
<td>.060</td>
<td>.009</td>
<td>-.085</td>
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<td>Arithmetic</td>
<td>.003</td>
<td>.171</td>
<td>.237</td>
<td>-.003</td>
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<tr>
<td>Similarities</td>
<td>.124</td>
<td>.492 &lt; 0.01</td>
<td>.178</td>
<td>.133</td>
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<tr>
<td>Vocabulary</td>
<td>.001</td>
<td>.135</td>
<td>.163</td>
<td>.041</td>
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<tr>
<td><strong>Performance Subtests</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Picture Completion</td>
<td>.165</td>
<td>.506 &lt; 0.01</td>
<td>.131</td>
<td>.177</td>
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<td>Picture Arrangement</td>
<td>-.104</td>
<td>.110</td>
<td>-0.25</td>
<td>-.038</td>
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<tr>
<td>Block Design</td>
<td>.390 &lt; 0.05</td>
<td>.203</td>
<td>.498 &lt; 0.01</td>
<td>.360 &lt; 0.05</td>
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<tr>
<td>Object Assembly</td>
<td>.384 &lt; 0.05</td>
<td>-.002</td>
<td>.398 &lt; 0.05</td>
<td>.375 &lt; 0.05</td>
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<tr>
<td>Coding</td>
<td>.067</td>
<td>.241</td>
<td>.098</td>
<td>.117</td>
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<tr>
<td><strong>Piaget Tests</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Piaget Raw Score</td>
<td>1.000*</td>
<td>.404 &lt; 0.01</td>
<td>.825 &lt; 0.01</td>
<td>.971 &lt; 0.01</td>
</tr>
<tr>
<td>Clay Test</td>
<td>.404 &lt; 0.01</td>
<td>1.000*</td>
<td>.435 &lt; 0.01</td>
<td>.373 &lt; 0.05</td>
</tr>
<tr>
<td>Sugar Test</td>
<td>.825 &lt; 0.01</td>
<td>.435 &lt; 0.01</td>
<td>1.000*</td>
<td>.787 &lt; 0.01</td>
</tr>
<tr>
<td>Bars-Cylinders Test</td>
<td>.971 &lt; 0.01</td>
<td>.373 &lt; 0.05</td>
<td>.787 &lt; 0.01</td>
<td>1.000*</td>
</tr>
</tbody>
</table>

* $r = 1.00$ represents the self-correlation for the test indicated.
.834; clay test, .719; sugar test, .825; bars-cylinders test, .849.

The following correlations were obtained for the Piaget subtests:

<table>
<thead>
<tr>
<th></th>
<th>r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay and Sugar</td>
<td>.435</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Clay and Bars-Cylinders</td>
<td>.373</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Sugar and Bars-Cylinders</td>
<td>.787</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

Thirty-three of the 40 subjects, 82.5 per cent of the total sample, demonstrated the acquisition of the concept of weight on the three Piaget tests, thus receiving a score of 3 or 4. The remaining 7 subjects (19.5 per cent of the total sample) showed a grasp of the concept of volume; of these only 2 subjects achieved volume on all three tests, with the remaining 5 subjects doing so only on the sugar and bars-cylinders tests.

All subjects demonstrated conclusively Piaget's sequential development of notions of conservation. Thus, no one who achieved weight failed to achieve substance, while those who achieved volume invariably succeeded on the substance and weight problems. To refer back to the scoring method it will be recalled that it was developed and utilized so that each score represented success at prior levels.
The question can be raised as to why the five subjects mentioned above who achieved the level of volume only on the sugar and bars-cylinders tests failed to achieve it on the clay test. The answer becomes evident upon a careful examination of the questions used by the examiner in administering the Piaget tests. The equal displacement of the same amount of water in the various alterations of the clay ball could be satisfactorily attributed by the subjects to the constancy of the weight of the clay under all these conditions; the concept of volume was not essential for an explanation of this phenomenon. In the sugar and the bars-cylinders tests however, a clear (abstractive) separation of volume from weight is necessary for success. This fact may account in part for the relatively higher correlation obtained between the sugar and bars-cylinders tests than between the clay test and each of these two tests.

To determine the internal consistency of the Piaget test the Kuder-Richardson formula for estimating reliability (Guilford, 1950) was utilized. The overall reliability of the Piaget tests was .788.

Hypothesis 1. It was predicted that a positive and significant correlation would be found between the WISC Full Scale IQ scores and the Piaget Raw (highest)
scores. At the .05 level of confidence with an N of 40 and 38 degrees of freedom a correlation between Piaget and the WISC exceeding .312 would be needed to achieve significance (based on minimum r's derived from Fisher's Test of a Coefficient of Correlation for small samples, Guilford, 1950). The obtained correlation between the WISC Full Scale IQ and Piaget scores was .141, and therefore negligible.

However, that the two measures nevertheless tap in common certain cognitive areas is indicated by the obtained correlation of .374 (significant at the .05 level of confidence) between WISC Full Scale IQ and the Piaget clay subtest. (In the same direction, and approaching significance, was the correlation of .305 between the Piaget sugar subtest and the WISC Full Scale IQ). Thus, although the specifically predicted relationship failed to be supported, the above hypothesis may be regarded as essentially confirmed by the data.

**Hypothesis 2.** This hypothesis stated that a higher correlation would be found between Piaget scores and WISC Performance IQs than between Piaget scores and WISC Verbal IQs. Table 4 reveals that the correlation between Piaget and Verbal Scale IQ is .020, and between Piaget and Performance Scale IQ .272. Thus, while both correlations are low and nonsignificant, the difference
between them is in the expected direction.

Actually, the above expectation appears confirmed when the correlations between Performance Scale IQ and the Clay and Sugar subtest scores are considered. As revealed in Table 4, while only low correlations turned up between Verbal Scale IQ and any Piaget scores, significant relationships were obtained between Performance Scale IQ and the clay and sugar subtests (.391 and .333 respectively; significant at the .05 level of confidence).

Further inspection of Table 4 suggests the particular WISC subtests which contribute mostly towards the common variance: Picture Completion, Block Design and Object Assembly. Of particular note, and consistent with theoretical expectations are the consistent and significant correlations between Block Design and Piaget scores, as well as the appearance of a significant relationship between the Similarities subtest, as the only one in the Verbal area (.492, significant at the .01 level of confidence), and the Clay subtest. These relationships will be discussed later.

**Hypothesis 3.** This hypothesis stated that subjects of the average and bright normal IQ ranges would demonstrate the acquisition of the understanding of the concepts of conservation of substance and weight,
but not of volume. The results indicate that this prediction was confirmed. As can be seen in Table 2, 17 of the 20 subjects in the average to bright normal IQ groups achieved the level of weight, but not of volume. Of the three subjects who demonstrated the acquisition of volume, 2 came from the bright normal range, and one from the average range. Further inspection of Table 2 reveals that the mean Piaget scores for the above two groups are essentially identical, 4.4 and 4.1, reflecting average achievement of weight only.

Hypothesis 4. It was predicted that subjects of the superior and very superior IQ ranges would demonstrate the acquisition of the level of volume in addition to those of substance and weight. Table 2 indicates that only 2 subjects in each of these IQ categories attained this level. It may be noted that all other subjects in these groups who failed at the level of volume showed no difficulties in solving the substance and weight problems. As described under hypothesis 3, reference to Table 2 reveals that there were no differences in mean Piaget scores either between these two groups (4.6 each), or among any of the four groups.
CHAPTER V

DISCUSSION

Of central interest in the present study were the relationships between WISC IQ and Piaget scores, and the validation of the sequential progression in the acquisition of notions of conservation. Results were obtained in support of predictions relevant to these areas.

Piaget and Wechsler

Although no predictive statements can be made with respect to Piaget and Wechsler when Full Scale IQs are utilized, it is amply demonstrated that the two measures tap certain cognitive areas in common when particular subtests (in both measures) are involved. Of greatest interest—and of theoretical importance—is the existence of such a relationship with the Wechsler subtests of abstractive conceptual thinking. That only the similarities subtest (in the verbal area) along with block design and object assembly showed communality with Piaget tends to strengthen the implications in Piaget of an unfolding capacity underlying logical
operations, i.e., the solution of problems of conservation. In effect the data supplies mutual validation for both tests of those parts which deal with abstractive cognitive capacities. It is indicated that predictions along one (albeit restricted) intellectual dimension can be made from one measure to the other although generalizations should be made with caution since the obtained correlations are not high; the highest one (.498) accounts only for 25 per cent of the common variance. Needless to say the scope of generalizations is restricted to the particular age range utilized in the study as well as to its socio-cultural class.

The usefulness and the applicability of these tests of conservation can be shown for diagnostic purposes: where additional (confirmatory) information obtained from the Wechsler is needed, or otherwise, where the WISC is not feasible to use, information or knowledge about a child's abstractive capacities may be obtained through the Piaget tests; for example in borderline cases, or cases where conventional testing is not possible (due to bilingualism or verbal limitations).

Relevant to the above is the confirmation of a differential relationship between Piaget and Performance IQ from Piaget and Verbal IQs. It is suggested that verbal skills are not essential to the normal
acquisition of notions of conservation. This is consistent with Piaget's contention that verbal and particularly scholastic experiences are not of central importance in the development of logical thinking (Inhelder, 1943). Thus the usefulness of the Piaget test as a supplement or adjunct to verbal measures of intelligence, i.e., as a performance type test (as suggested above) is demonstrated. Of course, further research into its validity as well as improving its quantitative scoring aspects would have to be carried out first.

In general there appears to be sufficient independence between the two measures to indicate the usefulness of exploring additional relationships between the Piaget and particular cognitive, as well as academic, factors.

Performance on Tests of Conservation

The obtained results support Piaget's own finding with respect to the sequential unfolding of stages in logical reasoning, i.e., of the developmental and experiential aspect of cognitive ability. Most of the subjects in the study functioned at the expected level, manifesting on one hand full acquisition of notions of conservation of substance and weight, and
not having achieved as yet the next or volume stage. These findings do support Hunt's (1961) proposal that tests based on Piaget's theory can provide us with an ordinal scale of intelligence. Of course further validation and standardization would be required as well as refinements in administration and scoring.

With respect to the validity of the Piaget some elucidation of the nature of the cognitive capacities tapped is provided by the association with the WISC conceptual functions. Outside of this a meaningful set of external dimensions might be represented by occupational aptitudes. At the present time the only independent measures are those offered by Inhelder (1943) and applying to mental retardates. Although she did not offer objective statistical data to substantiate her claims, she described how, among adolescent retardates, different levels of Piaget functioning could be related to varying occupational skills. According to her, while the level of substance might enable a person to achieve moderate occupational success in janitorial activity, the weight level would render him trainable for higher gardening skills.

Assumptions about additional meanings would stem from Piaget's theoretical proposition that his tests are related to cognitive factors intimately bound
to developmental processes. These are probably related less to restricted cultural (academic) influences but are rather related to cultural experiences in the broad sense which are appropriate to major stages of normal growth. Probably, while enriched cultural (verbal and intellectual) stimulation may result in high performance on a conventional test, such enriched exposure does not assure a correspondingly high level of achievement on the Piaget tests of conservation. For an optimal performance on the latter, it appears that what is required is an assurance of what Hartmann (1958) includes under a concept of average expectable environment, implying the presence of a physical and social environment which will provide the child for his needs and promote his development.

Nor does practice in solving problems of conservation lead to an acquisition of these notions beyond one's age-appropriate Piaget level. This was evidenced by Smedslund's (1961) study, noted in Chapter II.

Still many areas of ambiguity remain. Since the sample in this study used only one Piaget level age range which is relevant to the development of notions of weight conservation, there is no way of predicting whether this will hold over the entire range of
cognitive development. For example, it may be plausible to assume that very bright 5 and 6 year olds (i.e., preoperational stage according to Piaget) would reveal acquisition of substance. The only study available at the present time is by Feigenbaum (1963) who found that for his sample of children 4 to 7 years of age, the stages of development in the acquisition of the conservation concept were not defined by definite age barriers, but rather descriptive general trends. His data also indicated that the children's grasp of the conservation concept tended to vary with their IQ and with the nature of the concrete experimental operations.

But Feigenbaum's study suffers from two serious criticisms: (a) His inclusion in the sample of 7 year olds, who, according to Piaget's theoretical formulation, are within the stage of concrete operations. A close examination of Feigenbaum's study indicates that the frequency of success of his subjects did gradually increase with age, and his significant finding was that "in the youngest age group there were some subjects who could solve most of the problems" (p. 429). (b) Feigenbaum ignores Piaget's crucial point of allowing for an ability on the part of subjects to modify their responses when given the opportunity of witnessing experimental evidence
contradicting initial incorrect responses. Further research in this particular area is obviously needed. Thus, further clarification of the relationship between Piaget and Wechsler goes beyond substantiating the obtained results, and points to the importance of extending such investigation of relationships to all ranges of IQ on the one hand, and the various chronological Piaget stages on the other.

It should also be pointed out that this study shed no light on the issue raised by Berko and Brown (1960) regarding the role of verbal behavior and particularly the difficulties inherent in Piaget's verbal interrogation approach. Although none of the subjects experienced any verbal difficulty (with such concepts as size, capacity, equality) it is conceivable that lack of such concepts may affect performance in younger subjects, or subjects from culturally impoverished environments.

Finally the question pertaining to the presence or nature of individual differences can be raised (even relating to the abstractive area) for individuals who are functioning at the same Piaget level. Related to this is the problem of the nature of deviations in cognitive development and their effect upon, or manifestations through, logical operations.
CHAPTER VI

SUMMARY AND CONCLUSIONS

Problem

The general purpose of this study was to investigate the relationship in children between a conventional test of intelligence (the WISC), and their level of logical reasoning, as measured by Piaget's tests of conservation.

The following hypotheses were advanced:

1. That a significant and positive correlation would be found between WISC Full Scale IQ scores and Piaget scores.

2. That a higher correlation would be found between Piaget scores and WISC Performance IQs than between Piaget scores and WISC Verbal IQs.

3. That nine to ten year old subjects of average and bright normal IQ ranges would demonstrate the acquisition of the understanding of concepts of conservation of substance and weight, but not of volume.
4. That nine to ten year old subjects of superior and very superior IQ ranges would demonstrate the acquisition of the level of volume in addition to those of substance and weight.

**Method**

Forty boys, within the age range of 9 years 0 months to 10 years 4 months were assigned to four groups differentiated on the basis of the following Wechsler intelligence classifications: average, bright normal, superior, and very superior.

The subjects were screened for gross emotional, physical or neurological disorders, and all attended their appropriate grade levels. All were residents of West Los Angeles from middle to upper class Jewish homes who attend private parochial school twice a week in addition to regular Los Angeles elementary schools.

Each subject was first given the WISC; during a second interview following a 15 minute recess, the Piaget test was administered, the examiner eliciting in a directive but supportive manner the subject's notions concerning the principles of conservation of substance, weight and volume, as well as his ability to adapt his thinking, if incorrect, to experimental facts as presented to him. The Piaget test consisted of three
subtests:

1. In the first, or Clay test, the subject indicated whether or not he believed that a clay ball, deformed in various ways, or broken into small pieces, would retain (in terms of a comparison with another identical clay ball) its original quantity, weight, and volume.

2. In the sugar test, the subject was asked what would happen to a sugar tablet dissolved in water, whether it would disappear entirely or would remain somehow; whether the increment of weight due to the addition of sugar would remain after its dissolution; and whether the level of the water that rises when the sugar is added will return to its original stage as the sugar dissolved.

3. In the bars-cylinders test the subject's ability was investigated to determine if he could deduce weight equivalence of homogeneous elements as well as heterogeneous elements; and volume equivalence of these same varied elements, plus additional materials such as different weights and lengths of cylinders.

A scoring method was devised to reflect three main types of performance on the Piaget tests: (a) a lack of notions of conservation with inability to profit from experimental verification; (b) a spontaneous
demonstration of possession of notions of conservation; and (c) initial failure followed by modified responses in the light of corrective experience.

The highest subtest Piaget score represented the highest level of achievement for each subject. An additional scorer scored the data obtained to insure reliability of the scores. It was demonstrated that the three subtests intercorrelated while the overall reliability of the tests was determined by use of the Kuder-Richardson formula for estimating reliability.

**Results**

The results showed that:

1. Although a negligible correlation was found between WISC Full Scale IQs and Piaget scores (.141), a correlation of .374 (significant at the .05 level of confidence) was obtained between WISC Full Scale IQ and the Piaget Clay subtest.

2. Although negligible correlations were found between Piaget and WISC Performance Scale IQ as well as between Piaget and WISC Verbal Scale IQ, the expectation of a higher correlation between Piaget and the Performance Scale appeared to be confirmed when the correlations between Performance Scale IQ and the Piaget Clay and Sugar subtests were considered (.391 and .333 respectively; significant at the .05 level of
confidence). The Performance subtests which contributed mostly towards the variance were Picture Completion, Block Design and Object Assembly.

Correlations between each Piaget score and the WISC Verbal Scale IQs were low and nonsignificant. The only verbal subtest which appeared to have a significant relationship with the Piaget was the Similarities test.

1. The prediction that the average and bright normal IQ ranges would demonstrate the acquisition of substance and weight, but not of volume, was confirmed.

2. The prediction that the superior and very superior IQ ranges would demonstrate the acquisition of the level of volume was not confirmed.

Conclusions

The results indicated that the two tests tap restricted ranges of cognitive functioning in common, mostly in the abstractive areas. This may express the fact that while the Wechsler is a strong measure of verbal (and culturally determined) intellectual achievements, the Piaget is more closely related to developmental, epigenetic forms of cognitive behavior which result from the interaction between maturational processes and environmental influences.

The evidence in this study indicated that very superior and superior subjects in terms of WISC IQs are
not able to transcend their age-appropriate Piaget level. This supports Piaget's contention that the development of reasoning abilities is relatively free from specific scholastic influences. In this regard it is noteworthy to quote Inhelder, who, discussing the various factors affecting people's reactions to the Piaget tests, states:

If we nevertheless obtain in the face of this diversity of conduct a common mode of reasoning, then it is our choice of tests, no less than of method, which permits us to isolate the functional nucleus of thought from the array of other mental manifestations. The conservation problems highlight the functioning of intelligence independently of contingencies deriving from the verbal and memory acquisitions or in particular from scholastic training (1943, p. 266).

It may thus be plausible to interpret the obtained correlations between Piaget and Verbal and Performance scores as indicating that the Piaget test, in comparison with conventional tests, is relatively free from verbal and scholastic influences.

It is thus plausible to explain the failure of higher IQs levels to be differentially correlated with the Piaget in terms of the fact that we are dealing with two measures, both involving cognitive operations, but nevertheless embodying certain basic differences. While Piaget (theoretically and apparently empirically) involves different (or additional) mental operations between one stage and the next, this is not the case
with the Wechsler. The WISC lacks a theoretical rationale and its standardization and statistical derivation of IQs is predicated on higher IQs resulting from either more efficient functioning and/or a higher level of performance on tests of the same basic nature, e.g., it can readily be seen that a higher score on the WISC can be obtained by answering a few more items on some or all of the subtests.

Since the sample in this study uses only one Piaget level age range which is relevant to the development of notions of weight conservation, there is no way of predicting whether the lack of a significant relationship between Piaget and the WISC Full Scale will hold over the entire range of cognitive development. Further investigations are needed of all ranges of IQ as they are related to the various chronological Piaget stages.

In general, since Piaget's tests of conservation represent points of integration of the child's experiences and knowledge into concrete and logical levels, and since these successive integrations or logical groupings may represent basic mental structures which underlie and mediate the child's approach to everyday problems and situations, Piaget's method promises to provide a natural ordinal scale of intelligence with a
far greater degree of generalization than is possible with conventional scales of intelligence. As Hunt (1961) points out, such a scale could lend needed precision to the description of variations among the thought processes of children and adolescents. Moreover, by correlating each stage with educational and occupational accomplishments, i.e., by finding the appropriate "match" between available logical operations and occupational or scholastic expectations, the scale could serve as a practical tool not only for differential intellectual diagnosis, but also for predicting occupational and academic success.
APPENDICES
APPENDIX A

CONCEPTIONS OF INTELLIGENCE: A HISTORICAL SURVEY

Introduction. Even though the controversy over whether intelligence is due to nature or nurture has been superseded in recent years by a conception of an interaction of the two, a persistent belief in the important role of hereditary factors has continued to affect most theorizing about the nature of human intellectual abilities. Conventional tests of intelligence, moreover, lacking a basis in a theoretical rationale, have lent support to this belief in spite of attempts to link intelligence to certain selective external criteria. Thus, present conceptions of intelligence fall into three main types: (a) genetic intelligence, (b) test intelligence, and (c) developmental intelligence.

Genetic Intelligence. A genetic approach to intelligence must relate to--and indeed ultimately be based upon--conceptions of the biochemical and physiological structures determined at conception by the
genetic structure of the individual. Early theorists on
the nature of intelligence did not rely on such neuro-
psychological conceptions, nor did they regard experien-
tial influences as important for intellectual development.
Thus, they tended to confuse hereditary with environmental
factors and to blur the very distinction which had been
attempted by the differentiation between the genotype and
phenotype. Several lines of reasoning have underlain the
belief in innate intelligence.

1. The concept of fixed intelligence. Boynton
(1933) defined intelligence as an inherited capacity of
the individual which is manifested through his ability
to adapt and to reconstruct the factors of his environ-
ment in accordance with his group. Burt, Jones, Miller
and Moodie (1933) similarly stated: "By intelligence
the psychologist understands inborn all-around intellec-
tual ability. It is inherited, or at least innate, not
due to teaching or training; it is intellectual ... and
remains uninfluenced by industry or zeal" (pp. 28-29).
In a recent publication, Hunt (1961) has singled out two
assumptions which, achieving the status of "basic faiths"
have shaped the view that intelligence is the capacity
determined by genetic inheritance. These beliefs are the
assumption of fixed intelligence and the notion of pre-
determined development. Taken together "... the
assumptions or faiths justify the notion of intelligence as an innate dimension of personal capacity which increases at a fixed rate at a predetermined level. In other words, they justified the notion of constant IQ" (p. 3). Hunt cited several sources of empirical support for the belief of fixed intelligence: (a) improvement in performance with age; (b) constancy of the IQ, both in terms of average IQ constancy from age to age, and from test to test in individual children through the school years to adulthood; (c) intercorrelation of test scores; (d) validity of intelligence tests in terms of predicting school achievement as well as success in various other lines of endeavor; (e) hereditary versus environmental determination, based on correlations between the test scores of people of varying degrees of genetic relationship, as well as between people having no genetic relationships and on foster home and orphanage studies.

2. Predetermined development. The belief in predetermined development was based primarily on observations of "unlearned", instinctive-type behavior. It drew its empirical support from two main sources (Hunt, 1961): (a) Anatomical and behavioral development. Observations of stages of physical development of low and high order of animals revealed lawful sequences of maturation which
appeared to be uninfluenced by the circumstances of development. This was interpreted to show maturation as an unfolding of structures and behavioral patterns determined by inheritance. With regard to children, for example, Shirley (1931) concluded: "Motor development sweeps in an orderly course and apparently is little influenced by the exigencies of time, place and cultural fashion in child dress and child training" (p. 205).

Variations in experience and their effects on the course of development. Various investigations carried out on both animals and humans were aimed at determining the selective roles of learning versus maturation. Munn (1950) has reviewed studies on the animal patterns of behavior involved in sex and the care of the young. The evidence pointed to structural growth as the determining factor; previous relevant experience was of no consequence. Data yielded by studies on frogs and the pecking response in the chick were similarly interpreted (Carmichael, 1926; Cruze, 1935). Using the digit span as a task, Gates and Taylor (1925) had two matched groups of four year olds, one of which was given practice in memorizing digits over a period of about three months, the other group receiving no practice. Following a lapse of four months, without practice for either group, the experimental group was shown to have lost its
originally acquired superiority over the control. This result was interpreted as reflecting a maturational capacity underlying the immediate memory function. Similar conclusions were derived from results of studies in which groups of children, some twins, were compared immediately following differential experiences on various motor tasks, and then compared again some time later (Gesell and Thompson, 1938; Hilgard, 1932, 1933).

3. Factor analysis. Although many factor analysts have conceived of intellectual factors as descriptive dimensions, others have assumed these factors to represent genuine fixed causal additives of ability. Spearman (1904, 1923) was first to propose a general, or g factor, representing "general mental energy" to which later he added the s factors conceived as specific neuronal patterns underlying different activities. Cronbach (1960) has noted that the very use of the term "intelligence" or "intelligence tests" connotes some inborn mental superiority, while Sarason and Gladwin (Masland et al., 1958) similarly commented on the assumption which is strongly implied in the literature on mental and educational retardation that "intelligence is a thing" (p. 160). Ferguson (1956) pointed out that one prevalent definition of the term ability refers to some attribute of the organism or person which "may be
identified vaguely with neurophysiological structure and process which is modified by environmental and genetic factors." A strictly genetic point of view is still sometimes adopted, although the trend is away from it and towards its interaction with environmental influences. Thus, Halperin (1945) and Moore (1929) have ascribed to morons a genetically inferior endowment which renders them—following evolutionary principles—unable to compete socially in a capitalistic society. Pinneau (1955) in his critical evaluation of Spitz's study with institutionalized children also raised the possibility of the existence of a genetically inferior stock in one of the groups. Guilford (1956), on the other hand, dismissed the hereditary-environmental problem with regard to intelligence in general only to apply it again to specific factors: "The question 'is intelligence inherited or is it acquired' makes less sense than it ever did. Such a question must be asked regarding each and every factor" (p. 287). Guilford has identified—as have some other factor analysts—as some 40 factors while forecasting many additional unknown ones.

Test Intelligence. Mental testers after Binet have followed his example of approaching intelligence empirically and have regarded it as a general mental ability represented by certain kinds of higher mental
functions. Their tests, characterized by adequate standardization and statistical refinement, were pre-dicated essentially on discriminating power and on a performance-evaluating orientation (Freeman, 1957; McClelland, 1951). Consisting of measures presumed to be related to higher mental functions, the tests were applied mainly in two directions: prediction of school success and estimation of a psychological attribute considered to be distinct from educational achievement (Cronbach, 1960). While the tests were shown to be related to scholastic (and other) attainments, many authors questioned that they also assessed intellectual potential; these authors moreover questioned the relevance of many items to the functions tested (Eells et al., 1951; Guilford, 1956; Inhelder, 1944; Masland et al., 1958). McClelland (1951) for example, discussing the Wechsler-Bellevue Intelligence Scale as illustrative of the status of conventional tests, noted with regard to the various subtests that although Wechsler "... recognizes the importance of defining what his tests measure, he does not specifically state anywhere how each of these particular mental functions is related to the task in question" (p. 167). In its broad and all-encompassing terms, Wechsler's (1944) definition of intelligence as "the global capacity of the individual
to act purposefully, to think rationally, and to deal effectively with his environment" (p. 3) is also representative of other attempts to describe intelligence. However, in spite of considerable communality, the various definitions reveal different emphases (social, abstractive, practical, etc.), reflecting the lack of agreement as to the relative importance of particular 'high functions' or the intellectual activities underlying them (Anastasi, 1958; Freeman, 1957; McClelland, 1951). While the multiplicity of terms used by different authors may largely reflect semantic differences (Cronbach, 1960; Bells et al., 1951; Hunt, 1961), it appears also to indicate conceptual differences based on considerations of environmental factors (Spiker and McCandless, 1954), changing cultural patterns (Anastasi, 1958; Hunt, 1961) and research findings (Guilford, 1956).

It is generally agreed that in spite of their limitations, traditional tests of intelligence possess great practical usefulness (Anastasi, 1958; Cronbach, 1960). On the other hand, certain frequent criticisms of conventional tests imply that their only raison d'être is their prediction of school performance, which is the main referent for their operational definition. McCandless (1952) has noted the failure of many authors to realize that "... the construction of an
intelligence test is actually a definition of 'intelligence' " (p. 675); Masland et al. (1958) drew attention to the fact that there was really no other available way of operationally defining intelligence than by the IQ or its equivalent; and Eells et al. (1951), emphasizing the lack of theoretical basis for traditional tests of intelligence, nevertheless pointed out that from a practical point of view

Test intelligence can . . . be conveniently considered also as a concept in its own right. It derives its significance chiefly on an empirical basis. If the test items are chosen and standardized in such a manner that the test gives a true prediction of ability to perform school work, or in terms of any other selected criterion, that criterion becomes a definition of intelligence, and the question of whether the items are valid or not fails to arise. No item that correlates positively with the outside criterion can be ruled out as extraneous or invalid by saying that what it measures is not "intelligence" . . . if at the outset the criterion . . . has been accepted as a working definition of intelligence (p. 71).

Several authors have expressed their dissatisfaction even with this operational approach, mainly because of its scientific nearsightedness and impracticality in actual application (Cronbach, 1960; Hunt, 1961; Masland et al., 1958). The sharpest criticisms of conventional tests, however, have been directed at their verbal loading, cultural bias, and restricted range (Davis, 1948; Guilford, 1956; Haggard, 1954). Masland et al. (1958) have summarized and expressed very
succinctly these commonly held criticisms as follows:

1. Conventional tests sample a very limited number of intellectual processes, for the most part those kinds of processes which are required in scholastic achievements.

2. Conventional tests, by virtue primarily of their content and means of validation, contain a large element of social class or cultural bias.

3. There is no evidence that the level and kind of problem-solving behavior signified by scores on conventional tests are highly correlated with non-test problem-solving behavior.

4. It appears that the bulk of the mentally retarded are found primarily in the lower social classes and that the cultural matrix in these classes is different in important respects than that of other groups. Because of the cultural bias in conventional tests, the intellectual potential of this group, as well as its level of functioning outside the test situation, cannot be assumed to have been adequately assessed.

5. It is becoming more and more apparent that the variety of intellectual processes is far greater than had been thought previously to be the case and that the continued use of conventional tests and test scores in practice and research is likely to be, at best, nonproductive . . . (p. 194).

Of the above criticisms, the one pertaining to social class and cultural bias has been most extensively investigated. The Chicago group in particular has made it a focal point of its studies, contending and producing results showing that tests of intelligence (because of their content) are handicapping to the low status child, and that social class differences in performance therefore result from the way tests of intelligence are
constructed rather than from deficiencies in reading ability among lower class children. In spite of the impressive evidence supporting this argument, studies by Stroud (1942) and by Turnbull (1951) showed that tests are not biased against lower class children; when test scores of middle class and lower class children were matched, the former tended to do somewhat better in school; if anything, the test appeared not to give the middle class group enough advantage. This finding suggested that far from being inherently unfair to low status groups, tests only reflect (as does the school) the predominant cultural values of our society.

Stressing the circularity in conclusions such as the above and reiterating the cultural bias in conventional tests, Davis and Bells (1956) developed a new group test, the Davis Bells Games, which, while requiring reading ability deals primarily with everyday situations rather than with abstractions. It was expected that the test would provide a basis for more realistic estimates of the ability of children to cope with their over-all environment; it was also expected that the Index of Problem-Solving Ability derived from the test would not correlate highly with standard achievement tests because of the lack in the Davis Bells of emphasis on memory and efficient work habits. The
evidence so far fails to support the above expectations. Davis and Eells (1956) and Zweibelson (1956) actually found low but significant correlations with various achievement tests. Papania, Rosenblum, and Keller (1955), comparing the performance of 30 lower class non-organic retarded children on the Davis Eells Games with that on the Wechsler Intelligence Scale for Children, the Stanford-Binet Form L, and the California Mental Maturity Test, found that their subjects' mean score was lower on the Davis Eells Games Test than on any of the other tests. Other studies found that lower class children lagged just as far behind the middle class group on the Davis Eells as on conventional tests (Altus, 1956; Angelino and Shedd, 1955; Coleman and Ward, 1955); another study yielded results indicating a smaller correlation with social class for the Davis Eells Group Test than for the conventional tests (Noll, 1958) and another study revealed just the opposite, the lower class group having a relatively greater handicap on the Davis Eells (Fowler, 1957).

The Davis Eells Games may be considered a "culture fair" test, inasmuch as its authors have attempted to construct a test that avoids social class bias within the limits of English speaking urban children in the United States. Although it is generally
recognized that no test can avoid particular cultural influences (Anastasi, 1958; Eells, 1953; Gladwin and Sarason, 1953), a "culture free" test of intelligence was offered by Cattell (1940). Somewhere between this test and the "culture fair" test of Davis and Eells stand such "non-cultural" performance tests as the Leiter International Performance Scale (Arthur, 1952), the Raven Progressive Matrices (1951), and the Porteus Maze Test (1937). The latter scales, partly because of their non-verbal nature, have been widely applied in cross-cultural testing, with findings, however, indicating the differential effects of certain (e.g., educational) experiences in various cultural groups (Berlioz, 1955; Havighurst and Hilkevitch, 1944; Higgins and Sivers, 1958; Kluckhohn and Leighton, 1946; Ombredane, 1956; Rohrer, 1942; Sparling, 1941; Sperrazzo and Wilkins, 1958; Wrightstone, 1960). This fact was recognized by both Raven (1951) and Porteus (1939). Cattell's contention of having produced a "culture-free" test, on the other hand, was strongly disputed; the test, which comprises combinations of geometric figures tapping understanding of series relationships, classification, relational and sequence matrices, and mirror images, was shown to be culturally biased in its content and to be based on insupportable assumptions (Anastasi and
Cordova, 1953; Eells, 1953). Masland et al. (1958) made a most pertinent critical comment when they noted that no test could be completely culture-free "if for no other reason than the very concept of testing is itself at home in only a few cultures, principally our own" (p. 275).

The above brief review suggests that "non-conventional" tests are subject to the same shortcomings that their authors find in conventional scales. Together they suffer mostly from an overdependence on empirical considerations, from lack of theoretical foundation, and from failure to account for emotional as well as motivational factors (Bray, 1954; Masland et al., 1958; McClelland, 1951).

**Developmental Intelligence.** The concept of developmental intelligence expresses the view that intellectual development and ability result from the continued interaction between the organism and his environment. According to this view, fashioned after modern geneticist principles (Dobzhansky, 1956), the genes provide controlling directives for development and set limits for the range of intellectual variation, while experience—within this range—limits (or maximizes) intellectual development as well as affects its rate and direction. Thus, instead of ascribing a major
role to either heredity or environment, or determining a fixed proportion representing the contribution to intelligence of each of these two factors (Eells et al., 1951; Hunt, 1961), developmental approach conceives of a dynamic interaction between the two terms such that differences in intelligence occur at the point of determining the relative importance of each factor in the interaction.

Considerable evidence exists which lends support to the conception of interactionism and its two main propositions that (a) maturational processes themselves may be in part a function of stimulation and exercise; and (b) that duration and nature of experiences—especially in early development—play a crucial role in determining the organism's subsequent problem-solving (and other) abilities. The second proposition, moreover, is consonant with the theorizing of Harlow (1949), Hebb (1949) and Osgood (1953) on the role of early or "primary" learning. One of the clearest demonstrations of interaction between genotype and environment involves alterations of certain characteristics (including sex) in certain strains of fly through manipulating the conditions under which their development occurs (Hogben, 1939; Horsfall and Anderson, 1961; Sinnott et al., 1958). Another line of evidence derives from observations of
the perceptual behavior of animals subsequent to earlier visual insufficiencies or deprivations. Brattgard (1952), using rabbits, and Riesen (1947) with chimpanzees have shown that maturational perceptual disturbances result from metabolic insufficiency associated with drastic reduction of visual stimulation. (Examples of similar findings in other species may be found in Levine (1945) and Riesen, Kurke and Mellinger (1953). On the human level, Jervis (1938-1939) has traced the relationship between an enzyme disturbance and a type of feeblemindedness (phenylketonuria), and has shown, moreover, that a corrective measure (special diet), if applied early enough in the child's life, may serve to check the retardation. Pasamanick, Knobloch and Lilienfeld (1956) have shown that certain deficiencies in maternal diet associated with socioeconomic level can lead to complications of both pregnancy and parturition which result in intellectual retardation as well as behavioral disorders in their offspring. Harrell, Woodyard and Gates (1955) have demonstrated a relationship between improved diets of nutritionally deficient mothers and an increase in IQ in their offspring. That enriched early experience improves while lack of early stimulation stifles the capacity of an organism to profit from experience and to solve problems was shown in
the chimpanzee (Riesen, 1947), on dogs (Thompson and Heron, 1954), and even with rats (Hymovitch, 1952; Forgays and Forgays, 1952; Forgus, 1958; Gibson and Walk, 1956; Hebb, 1949). At the human level, the rate of development (physical, emotional and intellectual) in orphanage inmates—who are exposed to a dull, homogeneous environment—has been known to lag behind the typical rate (Dennis, 1960; Goldfarb, 1943, 1944; Skeels, Updegraff and Wellman, 1938; Spitz, 1945, 1946); stimulating experiences, on the other hand, lead to the opposite result, both with normal and retarded children. Hunt (1961) for example, reports on a project at the University of Illinois which showed that when high school students were given the opportunity to proceed at their own speed (that is, in keeping with their state of readiness) in learning mathematics, marked individual differences in achievement soon occurred, requiring the splitting of classes. Kirk (1958) followed for several years a group of retarded children with ages between 3 and 6 years and with IQs ranging between 45 and 80. He reported that 30 (70 per cent) of a group of 43 retarded children who were given special nursery school experiences, showed an acceleration in rates of intellectual growth ranging from 10 to 30 IQ points. The average increase in IQ for the experimental
group was significantly greater than that for two control groups. Moreover, the children in the experimental group retained their accelerated rates of growth when followed up again between 3 to 5 years later.

Many studies and considerable theorizing bear directly on two basic propositions of the developmental approach. The first proposition relates to a "state of readiness" on the part of the organism, in terms of response repertory to profit from further experiences; the second suggests that intelligence is not a fixed quality, but rather represents a child's intellectual ability as measured at any point in his development. The first hypothesis has been treated theoretically (though under different terms) by several authors (Festinger, 1957; Fuller and Scott, 1954; Hebb, 1949; Miller, Galanter, and Pribram, 1960) and has been demonstrated by Greco 1959, Goustard (1959), Matalon (1959), McGraw (1935), Scott (1945) and Smedslund (1961). For example, Scott, Frederickson and Fuller (1951) have found a number of distinct natural periods in the development of the dog and have shown that only one of them represents a "critical stage" during which conditioning (habit training) can be accomplished. Investigating the concept of number in children, Wohlwill and Lowe (1962) discovered that training children under six
in the solution of conservation problems produced only
restricted temporary and non-generalizable gains; acqui-
sition of the principle of conservation in children has
been demonstrated to appear somewhat later (Piaget and
Inhelder, 1941).

The concept of developmental intelligence (relat-
ing to a child's present ability) has, on the other hand,
had certain difficulties. Predicated upon the notion of
a dynamic interaction between the growing child and his
everyday experiences, it has lacked normative data re-
flecting this interaction at different stages of develop-
ment; and being dissonant (Hunt, 1961) both with
descriptive developmental norms and the notion of an
essentially fixed IQ, it has had to employ a broad de-
finition of intelligence in terms of "problem-solving"
ability. Thus, it is not surprising that most of the
findings underlying the notions of developmental intelli-
gence were derived (at least on the human level) from
fairly extreme cases and that they were often interpreted
in terms of the genetic approach (Hunt, 1961).
APPENDIX B

THE DEVELOPMENT OF PIAGET'S THEORY: A HISTORICAL SURVEY

Over the past thirty years Professor Jean Piaget and his associates at the Institute Jean Jacques Rousseau in Geneva have published more than 180 studies on the psychology of intelligence, among them 21 full-length books and numerous monographs. The experiments and observations described in these volumes are the foundations on which Piaget has constructed a genetic theory of knowledge which postulates that motor action is the source from which mental operations emerge (i.e. thought arises from sensorimotor activity); that man's knowledge about the world derives from his concrete experiences with it; and that the unfolding of man's psychological potentialities exposes him to an ever-expanding sector of reality (Wolff, 1960).

The central assertions of the theory are that:
(a) Intelligence is only one aspect of the general biological adaptation to the environment (Piaget, 1936, p. 31).
(b) Intellectual adaptation is the progressive
differentiation and integration of inborn reflex mechanisms under the impact of experience. "Life is a continuous creation of increasingly complex forms and a progressive balancing of these forms with the environment" (p. 3). (c) The differentiation of inborn reflex structures and their functions gives rise to the mental operations by which man conceives of objects, space, time, and causality, and of the logical relationships which constitute the basis of scientific thought (p. 407).

One of the major goals which has animated Piaget's work is to formulate a theory of knowledge rooted in biological principles and based on empirical findings. His intention was to write the ontogenetic history of cognition, and not to give an account of early personality development. Considered as a whole, his writings are a theory of knowledge more than a psychological theory of development, and as such they are a subject matter for the philosophy of science. However, since Piaget derived his theory of knowledge from studying the ontogenesis of actual thought processes, and obtained his data by the clinical and experimental methods of psychology, his writings also imply a psychological theory which can be extracted from his general theory.

Piaget's method of investigation (Wolff, 1960) is one of direct observation, ad hoc experimentation,
and scheduled interviewing. His data, although interpreted from introspective reports and in the framework of his theory, are behavioral and objective.

To begin with, from 1923 to 1932, already concerned with the task of finding a biological explanation of knowledge, Piaget began his psychological studies by systematically recording the verbal productions of 3 to 10 year old children. He collected and systematized the forms of verbal expression according to age levels, and demonstrated a lawful sequence governing the development of the child's reasoning processes, his use of language, and his conception of physical and social reality. The findings of these studies were reported in five volumes. "The Language and Thought of the Child" (Piaget, 1923) traces the use of language from the "egocentric" stage when speech is only the vocal accompaniment of the child's solipsistic thoughts, actions, and games, to the point of socialization, when it becomes a comprehensible and intentional tool for communication. "Judgement and Reasoning in the Child" (Piaget, 1924) explores the child's use of conjunctions such as "because", "therefore", "but", etc., his notions about the reciprocity of relationships and his notions of classes and relations at various ages. "The Child's Conception of the World", and the "Child's Conception
of Causality" (Piaget 1927a, 1927b) deal with the child's explanations of physical phenomena, of the origin of things and names, and of the causes which underlie physical and social events. "The Moral Judgement of the Child" (Piaget, 1932) deals with his judgement of social relationships as reflected in his group games and his relationships to authority figures. From these studies Piaget concluded that thought passes through a series of stages, from early animistic through magical and artificialistic forms to rational thought, and that at each level the child constructs a systematic "cosmology" of the world according to the modes of reasoning available to him at that stage.

During the first phase of his work Piaget concentrated on the content and form of the child's verbal behavior, and did not concern himself with the underlying mental processes. His assumption was that verbal intelligence is identical with intelligence in general, and that a chronological analysis of speech samples would demonstrate the mental mechanisms involved in intellectual development. But his studies led him to conclude that verbal intelligence is only one particular expression of mental functioning, and the concrete manipulation of objects another expression of the same processes; and that he would have to look beyond the
manifest verbal or motor behavior to find common laws of mental functioning covering both expressions of intelligence. In the second phase he therefore studied infants during their preverbal development and relied on the infant’s concrete manipulation of objects and responses to stimulation as the behavioral criteria from which he inferred the underlying mental processes (Wolff, 1960).

From 1936 to 1945 Piaget reported his observations on his own three children in "The Origins of Intelligence" (Piaget, 1936), "The Construction of Reality" (Piaget, 1937), and "Play, Dreams and Imitation" (Piaget, 1945). The first two volumes deal with the sensorimotor phase of development, i.e., with the development of motor functions and the acquisition of increasing skill in the manipulation of objects, while the third deals with the transition from sensorimotor intelligence to early symbolic activity as a substitute for motor action. Piaget adapted his clinical method to the nonverbal child by substituting games for conversations as experimental procedures, although he still allowed the child’s spontaneous play to determine what games he played. He made daily observations of the children and recorded their spontaneous behavior. Whenever his observations suggested a testable hypothesis
about the mental processes underlying their behavior, he carried out experiments to test the hypothesis. First he created the conditions under which he had made the observation in order to confirm its validity. Then he systematically varied the conditions in order to establish the limits within which the behavior was stable, and in order to test the variations in behavior due to the changing conditions. In this manner he tested the hypothesis as well as the limits of its validity.

In "The Origins of Intelligence" and "The Construction of Reality" Piaget reports together 365 observations and experiments of this kind. Piaget did not observe all the behaviors he reports in each of the children, nor was each child a subject for every experiment. But every major hypothesis was tested and confirmed by a "crucial" experiment with each child.

From his studies with children up to the age of four, Piaget set down general laws of intelligence development in terms of the underlying mental processes, and in the third phase of his work he tested their validity when they were applied to the development of intelligence from the age of five through adolescence. The focus of his investigation was no longer on the manifest content of behavior as such, but on the
processes of transformation which would account for a functional continuity between reflex behavior at birth and those intellectual functions by which the adult mind performs abstract logical operations, conceives of unperceivable (non-Euclidean) spaces, and calculates with imaginary numbers.

From 1941 to 1951 Piaget reported the findings of these studies in seven volumes dealing with the child's conception of number, quantity, time, movement and speed, space, geometry and probability.

In 1955 he published a comprehensive volume, "The Growth of Logical Thinking" (Piaget, 1955), which reported new experiments and summed up the previous findings in a general outline of the transformation of mental processes from concrete to logical operations. This completed 33 years of investigation of cognitive development.
APPENDIX C
APPENDIX C

QUESTIONS USED IN ADMINISTERING PIAGET TESTS

The Use of the Two-Platform Scale

1. You see this scale. See where the needle is. It is right in the middle. Now, if we put something on this side, where would the needle go?

2. And if you put something on the other side?

3. If we put two things on the scale and they weigh exactly the same, where would the needle be?

Clay Test

Substance and Weight

1. Now, here we have two clay balls. Let's put them on the scale and see if they are the same.

2. Now, take this clay ball and make a thin flat pancake out of it.

3. If you were to put these back on the scale, would the thin pancake weigh as much as the clay ball, or more, or less? Why?

4. A. (If correct) Doesn't it matter that the pancake is thin and flat and the ball is round and solid?

   B. (If wrong) a. Can you roll the pancake back into the shape of a ball?

      b. How would it compare to this
clay ball if you did roll it back, would it then weigh the same as the ball, or more, or less?

c. Do you still think the pancake will weigh differently than the clay ball? (Regardless of answer subject is invited to compare the two on the scale.)

(If still wrong) d. Is there as much clay in the pancake as in the clay ball, or more, or less? Why?

5. Now take the pancake and roll it into the shape of a hot dog.

6. If we were to put the hot dog on one side of the scale and the round solid ball on the other, would the hot dog weigh as much as the clay ball, or more, or less? Why?

7. A. (If correct) Doesn't it make any difference that here you have a long and thin hot dog compared to the ball which is round and solid?

B. (If wrong) a. Can you roll the hot dog back into the shape of the ball?

b. How would it compare to this clay ball if you did roll it back? Would it then weigh the same as the ball, or more, or less?

c. Do you still think the hot dog will weigh differently than the clay ball?
(Regardless of answer subject is invited to compare the two on the scale.)

(If still wrong) d. Is there as much clay in the hot dog as in the clay ball, or more, or less? Why?

8. Now take this hot dog and break it into many small pieces.

9. If you were to take all these pieces together and put them on one side of the scale, and the clay ball on the other, would the pieces together weigh as much as the clay ball, or more, or less?

10. Doesn't it make any difference that you have so many pieces?

Volume

1. Here we have two containers of water. Do they have the same amount of water in them?

2. What would happen if we put this clay ball in the water? Why?

3. Let's see how high do you think the water is going to go up when we put this ball in?

4. Let's make a mark at the level where the water is now, and we'll put the ball in and see how high the water actually goes.

5. Let's make a mark now at the level where the water went up. This is where the water was before and this is where the water is now after you put the clay
ball in. If we took this other clay ball and made it into a thin pancake and we put the thin flat pancake into the water in the beaker, would the water also go up?

6. Do you think the water would go up as high as it went up for the clay ball, or lower, or higher? Why?

7. What does it depend on as to how high the water will go?

8. Now suppose we take this clay ball and make it into a hot dog shape and we put the hot dog into this container would the water go up as high as the other container with the ball, or would it go lower, or higher? Why?

9. What does it depend on as to how high the water will go?

10. Now suppose we take this clay ball and break it into many small pieces, and then we put all the pieces into this container, would the water go up as high as the other container with the ball, or would it go lower, or higher? Why?

11. What does it depend on as to how high the water will go?
Sugar Test

Substance
1. See these two glass cylinders, they have the same amount of water in them. Let's make sure they weigh the same. What would happen if you put this sugar in the water?

2. What happens to the sugar when you can't see it anymore?

3. Is it still in the water even if you can't see it?

4. How can you tell it's there if you can't see it?

Weight
1. Now these two weigh the same. What would happen after we put the sugar in this glass cylinder? Are they still going to weigh the same or not? Why?

2. When we first put the sugar in, it would weigh a little bit more. How about when the sugar is fully melted and you can't see it? How would it be then? Would it still weigh a little bit more? Why?

Volume
1. What will happen to the water level when I first put the sugar in? Why?

2. Now let's put a mark here where the water comes to now. You show me where the water will be when
we put the sugar in. Let's make a red mark there. Now what will happen when the sugar is fully melted? Why?

3. Let me show you this piece of lead. Here is a piece of sugar. Which one do you think will weigh more?

(Confirmed)

4. If we were to put this piece of lead into the water, what would happen? Is the water going to go up any?

5. Now here is where the water is right now. How high would you suppose the water will go up for the lead?

6. And how high will it go up for the sugar? Why?

7. Let's try it. Where is the water higher? Why?

Bars-Cylinders Test

Weight

1. Now here is a red bar and a black bar. Do you think they weigh the same?

2. How can you tell? (Verified)

3. Now, how about this yellow bar and the black bar? Do you think they weigh the same?
4. How can you tell? (Verified)

5. The red and black weigh the same, and the yellow and the black weigh the same. Now, just by looking at the red and yellow (placed obliquely), tell me if they are going to weigh the same or not? Why?

6. Now, how about the blue and black, will they weigh the same?

7. How can you tell? (Verified)

8. Now, if we put on one side of the scale the red and blue standing on one end like this, and on this side the black and the yellow lying flat; now, we haven't weighed these two against the other two like this; how do you think they will compare? Why?

9. Here is a piece of wax and the red bar, do you think they weigh the same?

10. How can you tell? (Verified)

11. How about this yellow bar and this piece of lead?

12. How can you tell? (Verified)

13. Now, just by looking at this wax and this piece of lead, how would they compare if we placed them on the scale?

14. Why? We haven't weighed this against that yet?
15. Now, if on this side we had the lead, the wax, and the yellow bar, and on the other side we had the red, black, and blue bar, how would they compare? Why?

16. If we had the wax and lead on one side, and the blue and black bar on the other side, how would they compare? Why?

17. Now, if on this side we had the lead, yellow bar, this green clay, and on the other side we had the wax, and red bar, and black bar? Why?

**Volume**

1. Here are the two big containers of water. Remember they are the same. They have the same amount of water in them. What would happen if we put the yellow cylinder in one, and the black cylinder in the other? Why? (Verified)

2. What would happen if we put the red cylinder in one, and the black cylinder in the other? Why? (Verified)

3. Now, we tried the yellow and the black, and the red and the black, but we haven't compared the yellow and the red. Before we put them in, suppose that on this side we have the red cylinder lying flat, and on this side, the yellow standing upright like this. How would it be then? Are they going to make the water
go up the same or not? And if not, which one will make the water go up more?

4. Now let's try the yellow and black lying down in this container, and the longer plain one standing straight in the other container. How would it be then? Are they going to make the water go up the same or not? And if not, which one will make the water go up more?

5. Now, let's try the yellow cylinder and this plain one. Are they the same? Do they weigh the same? Let's put them on the scale and see. (Plain cylinder weighs more)

6. Now we know how high the yellow one makes the water go up. How high will the plain one make the water go up; as high, lower, or higher than the yellow one? Why?

7. Now try the three plain small cylinders against the long plain cylinder. How will they compare? Why?

8. Now try the three plain small ones plus the red one against the long plain one plus the black one. How will they compare? Why?

9. Now here is the metal cylinder and a ball of clay. Do they weigh the same? How do you know?

10. Let's see how high each one will make the
water rise. (Verify equivalence) Why?

11. Now here is the metal cylinder and this lump of wax. Do they weigh the same? How do you know?

12. Let's see how high each one will make the water rise. (Verify equivalence) Why?

13. Here are the yellow cylinder and the plain one. Do they weigh the same?

14. Now, let's try the yellow one lying down in this container, with the plain one standing up, and in this container the black one and the clay ball. Will the two cylinders make the water go up as high, or higher, or lower than the cylinder and the clay ball? Why?
APPENDIX D
APPENDIX D

SCORE SHEET FOR PIAGET TEST

Subject No.:__________________ TESTED:__________________

BIRTH DATE:__________________

C.A.:______YEARS____MONTHS

<table>
<thead>
<tr>
<th>Clay</th>
<th>Sugar</th>
<th>Bars-Cylinders</th>
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<tr>
<td>S</td>
<td>W</td>
<td>V</td>
</tr>
<tr>
<td>S</td>
<td>W</td>
<td>V</td>
</tr>
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<td>W</td>
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SCORING:

SUBTESTS:

CLAY:______

SUGAR:______

BARS-CYLINDERS:______

PIAGET HIGHEST SCORE:______

127
APPENDIX E
APPENDIX E

EXCERPTS FROM SAMPLE PROTOCOLS

Clay Test

Score of 3 (successfully modified response for weight acquisition), obtained by 28 subjects;

1. (With pancake) I think it would weigh less. (Why?) Because it is flat, it is not all together in a ball.

2. (Modified response after experimental evidence) Oh, oh, it is the same. (Why?) Because it is the same amount, because it is the same thing except it's in a different shape.

Score of 4 (weight acquisition at spontaneous level), obtained by 10 subjects;

1. The same. (Why?) Because it was originally the same amount and none has been taken away so it’s still the same weight.

2. No it doesn’t matter (the difference in shape). It could be shaped like a horse if the horse could be hollow it would still be the same amount of weight.

Score of 3 or 4 (indicating non-acquisition of volume), obtained by 38 subjects;

1. (What does it depend on how high the water . . .?) It depends on how much weight you put in. The hot dog would weigh the same as the clay ball as long as it weighs the same it should go up the same.
Score of 5 (successfully modified response for volume acquisition), obtained by 2 subjects:

1. (With pancake) It might go a little higher, I'm not so sure. (Why?) It takes up more space. (Why?) Because it would be flatter.

2. (Modified responses after experimental evidence) It would go as high ... because all the pieces together make the ball or a hot dog or a pancake ... because this is taking up room ... because you are not taking anything away from it.

Sugar Test

Score of 3 (successfully modified response for weight acquisition), obtained by 12 subjects:

1. (Acquisition of substance deal with by first responses) (What happens to the sugar ...?) It dissolves, the water picks it up, absorbs it. (Is is still in the water ...?) Sure, it's still in the water. (How can you tell ...) Oh, that's easy, just taste it, it would be sweet.

2. (What would happen after we put the sugar in ...?) They would weigh the same. (Why?) The sugar adds some weight, but it's so slight you wouldn't notice it.

3. (Modified responses after experimental evidence) (Would it still weigh more after you couldn't see
the sugar?} Sure it'll still weigh more because the water went up when you put the sugar in. The sugar changes to sugar-water and it'll still weigh more.

Score of 4 (weight acquisition at spontaneous level), obtained by 21 subjects:

1. (Why would it weigh more ... you can't see it ... ?) Yes, but there's still the same amount of sugar in there. It's in tiny pieces you can't see, but they're all there and they still weigh the same as before.

Score of 3 or 4 (indicating non-acquisition of volume), obtained by 33 subjects:

1. (Why will the water go up higher with the lead?) It weighs more than the sugar.

2. (Non-acquisition of volume responses after experimental evidence) (a) The water holds the sugar more firmly, and the lead is separated from the water. So the water is higher with the sugar.

   It's simple.

   (b) Yah, that's strange. I just don't know.

   (c) Because the water went into the sugar and made it heavier (than the lead).

Score of 5 (successfully modified response for volume acquisition), obtained by 7 subjects:

1. (The lead compared to the sugar) It would go higher.

   (Why?) Because it's heavier.
2. (Modified response after experimental evidence) The lead did! (Why?) Because this is bigger and takes up more room. (Does weight have anything to do with . . . ?) Not really. (What does it depend on . . . ?) How big the thing is.

Bars-Cylinders Test

Score of 3 (successfully modified response for weight acquisition), obtained by 10 subjects.

1. (Red and blue bars standing on one end compared to black and yellow lying flat) I think these will weigh more a little. (Why?) Cause these will be more on the scale, and these will be more off the scale.

2. (Modified response after experimental evidence) Well it doesn't make any difference how they're lying. They still push the same weight down . . . Each bar weighs the same so these two weigh the same as these two.

Score of 4 (weight acquisition at spontaneous level), obtained by 23 subjects:

1. This one weighs the same as this one, and this one weighs the same as this one, and those two weigh the same, so these two must weigh the same.

2. The same. (Why?) Because the red bar weighed the same as the wax, and the yellow bar weighed the
same as the lead, and the two bars weigh the same. See, it doesn't matter which one you weigh against which one cause they all weigh the same.

Score of 3 or 4 (indicating non-acquisition of volume), obtained by 33 subjects.

1. (The plain heavier cylinder compared to the yellow cylinder) The plain one will make the water go up higher cause it weighs more than the yellow one. (After experimental evidence) But that doesn't make sense. I don't know why it happened.

2. (Two heterogeneous cylinders compared to the cylinder and the clay ball) (Would the water go up the same distance?) Yes, it would, because it doesn't matter how you put them in, and the clay ball made the water go up the same as the plain cylinder, so together with one cylinder, it will make the water go up as high as two cylinders, but I don't understand why cause they don't weigh the same.

Score of 7 (successfully modified response for volume acquisition), obtained by 6 subjects.

1. (a) (The plain heavier cylinder compared to the yellow cylinder) The container filled with water with the plain cylinder in it would have the water go up higher. (Why?) Because it weighs more?
(b) (Modified response after experimental evidence) The same. (Why?) Because they are the same size. (What does it depend on . . . ?) On the size. (But they weigh different?) It's not the weight that counts, it's the size.

2. (After earlier incorrect response followed by experimental evidence) You could make the clay into the shape of that bar and they still wouldn't weigh the same, but they would be equal in shape and make the water go up the same . . . it doesn't mean if they weigh the same, it means how big the object is.

Score of 8 (volume equivalence of heterogeneous elements at spontaneous level), obtained by 1 subject:

(a) (Three plain cylinders compared to the big one) These three are the same size and thickness as the long one, so they'll make the water go up the same.

(b) (Metal cylinder compared to ball of clay) They made the water go up the same cause they're both the same bigness, they're just as big as each other. (Do these weigh the same?) We know they don't, but it doesn't matter, as long as they're the same bigness.
## APPENDIX F

### CORRELATIONS BETWEEN WISC IQS AND SCORES

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<th>Similarities</th>
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### Performance Tests

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<th>Block Design</th>
<th>Object Assembly</th>
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* * r = 1.00 represents the self-correlation for the test indicated.
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\( r = 1.00 \) represents the self-correlation for the test indicated.