THE EFFECT OF VARYING THE NUMBER OF IRRELEVANT ATTRIBUTES ON AREA CONSERVATION PERFORMANCE

by Stan J. Pasko

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CURRICULUM STUDIORUM

Stan J. Pasko was born February 23, 1936, in Fort William, Ontario. He received a Bachelor of Arts degree from the University of Western Ontario in 1961; a Bachelor of Education degree from the Ontario Institute for Studies in Education in 1963, and a Master of Education degree from the same institution in 1968.

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INTRODUCTION

Piaget began his study of intellectual growth in children some five decades ago. In his work, he shows that during any interaction with the environment, the human organism initiates adaptation procedures to restore or attain a state of equilibrium and that intelligence is reflected in behaviour which is maximally adaptive. Piaget also asserts that when these adaptive behaviours are analyzed, they form related clusters which reflect a progressive ability to handle information and which develop in an invariant order. One such cluster of logical abilities Piaget has labelled the concrete operational stage. Here, Piaget claims that children achieve the ability to deal logically with actions performed on concrete objects. Specifically, children at this level become conservers. That is, they recognize the invariance of quantities in spite of transformations or an emphasis of some irrelevant factor.

At the present time, Piaget and his associates have compiled a massive amount of data related to the development of logic in children as they judge notions of space, time, area, length, and number.

To determine the development of area conservation, Piaget studied children's responses when models of two cows, two fields, and some buildings were combined. The children were asked to determine the equality or inequality of the remaining grass areas which each cow would have left to eat after buildings were positioned on the fields. When the buildings were spread, nonconserving children tended to judge the remaining grass area smaller than the one where the buildings abutted one another. Piaget attributed such selections to the children's reliance on the perceptual arrangement of the buildings. According to him, as they grow older, children begin to make more use of a logic based on reversibility, compensation and identity.

Although Piaget has stressed the logical aspects of mental development, he has also recognized the influence of material conditions on this development. His theory, however, does not systematically provide for an interpretation of results which might well be a function of those same material conditions.

Flavell and Wohlwill have attempted to extend Piaget's theory by postulating a weighted (k) information processing factor (P_b) to systematically account for the variations in conservation performance which occur within a single domain. Flavell and Wohlwill propose the probability formula, [$P(+) = P_a \times P_b^{(1-k)}$], to relate the influence of task variables, (P_b), and the logical aspects of mental development, (P_a). The above formula, they maintain, will account for the inconsistent conservation responses given by children in the transitional stage.

One task variable which may influence the occurrence of a conservation response is the number of irrelevant attributes included in these tasks. Specifically in the present research, the question of whether conservation responses given by transitional children are affected by a variation in the number of irrelevant attributes during an area conservation test was investigated.

The thesis is divided into four chapters. In the first chapter a review of the literature which has been separated into six sections is reported. Piaget's theory of intelligence is outlined in the first section. Piaget's analysis of the logic inherent in children's responses during the area conservation test involving the cows, fields and buildings is delineated in section two. Flavell and Wohlwill's model of cognitive development is described in the third section. In the fourth section, Piaget's and Flavell and Wohlwill's models are compared. The role of irrelevant attributes is discussed in the fifth section while the research question is presented in the final section.

The research design is described in the four sections of the second chapter. The procedures to manipulate the number of irrelevant attributes and to measure conservation responses are detailed in section one. The experimental subjects are described in section two while the experimental procedure and statistical techniques for analyzing the data are discussed in sections three and four respectively.

The third and fourth chapters are made up of a presentation of the results and a discussion of these results respectively. The thesis is concluded with a summary.

CHAPTER I

REVIEW OF THE LITERATURE

In the areas of child psychology and education, Jean Piaget has been labelled as the "foremost contributor to the field of intellectual development"[1]. Furthermore, Ginsburg and Opper[2] also note, Piaget and his colleagues[3] have produced more valuable investigations and theory than any other individual researcher or group of researchers in child psychology. A large part of Piaget's[4] contribution to child psychology has been the novel and imaginative approaches which he has devised to explore children's notions of conservation. Conservation[5] is defined as the ability to recognize constant quantitative relationships in spite of changing information produced by perceptual variations.

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1 Herbert Ginsburg and Sylvia Opper, Piaget's Theory of Intellectual Development, An Introduction, Englewood Cliffs, Prentice-Hall, 1969, p. ix.

2 Ibid.

3 Among the many collaborators of Piaget, Barbel Inhelder and Alina Szeminska rank as the most important. All future references to the theory will be made only under Piaget's name.

4 Ginsburg and Opper, Op. Cit., p. ix.

5 Jean Piaget, Six Psychological Studies, New York, Vintage Books, 1968, p. 46.

Flavell and Wohlwill[6] also acknowledge the seminal nature of Piaget's work and its strong influence on their model of cognitive development. In their model, Flavell and Wohlwill attempt to account for a factor which they feel is not well defined in Piaget's work. This dimension is the effect of task variables, such as the number of relevant and irrelevant attributes, on conservation development. By systematically accounting for the influence of this factor, Flavell and Wohlwill claim that their model of cognitive development more adequately defines intellectual growth.

In the first section of this chapter, the Piagetian theory of intelligence is outlined. This is followed by a description of one of Piaget's area conservation tests and his interpretations of the different responses made by children during this test. The model proposed by Flavell and Wohlwill is described in the third section. In the fourth section, Piaget's and Flavell and Wohlwill's models are compared. The role of relevant and irrelevant attributes during concept learning is discussed in the fifth section

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6 John H. Flavell and Joachim F. Wohlwill, "Formal and Functional Aspects of Cognitive Development", David Elkind and John H. Flavell, (eds.), Studies in Cognitive Development, Essays in Honor of Jean Piaget, London, Oxford Press, 1969, p. 67.

while the research question is specified in the final section of this chapter.

1. Piaget's Theory of Intelligence.

For the past five decades, Piaget has researched and reported a cognitive development theory. In the first parts of this section, the factors and processes which Piaget claims are responsible for intellectual growth in general, as well as the resultant stages which describe the various levels of intellectual growth, are discussed. A description of how children acquire conservation during one of these stages, the concrete operational stage, is included in the final portion of the first section.

Intellectual growth, Piaget[7] postulates, occurs mainly because of the interaction between an organism and the environment and is effected by four interdependent factors; maturation, social interaction, physical experience, and equilibration.

Maturation or the growth of functional physical capacities such as the nervous system extends the development of the human organism from birth (embryogenesis).

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7 Jean Piaget, "Psychology and Philosophy", Benjamin B. Wolman and Ernest Nagel, (eds.), Scientific Psychology, New York, Basic Books, 1965, p. 33.

Generally, maturation determines developmental limits[8].

Social interactions such as inter-individual communications account for the knowledge that is acquired through any form of education. More broadly, this factor reflects the influence of language acquisition on development.

Physical experience involves actions upon objects. From such actions, knowledge about the objects themselves as well as knowledge from the actions is possible.

Equilibrations or self-regulations are compensatory systems offsetting external disturbances. Piaget considers equilibration the most fundamental factor and the one which subsumes the three other factors mentioned above. To Piaget[9], equilibration means the progressive internal organization of knowledge in a stepwise manner. These steps, Piaget[10] claims, reveal a growth from concrete forms of thinking to more abstract thinking modes, occur in a fixed sequence, can be clustered into substages as well as

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8 Barbel Inhelder and Jean Piaget, The Growth of Logical Thinking From Childhood to Adolescence, New York, Basic Books, 1958, p. 337.

9 Jean Piaget, The Psychology of Intelligence, London, Routledge and Kegan Paul, 1950, p. 49.

10 Jean Piaget, The Child and Reality, New York, Grossman, 1973, p. 10.

into four macroscopic stages[11,12], and occur at approximately the ages reported in the brackets. These stages and ages are: sensori-motor (birth to two years); preoperational (two years to seven years) which is subdivided into preconceptual (two years to four years) and intuitive (four years to seven years); concrete operational (seven years to eleven years); and formal operational (eleven years to fifteen years).

Moreover, Piaget[13] views intelligence as invariant processes of adaptation and organization which operate throughout life. Adaptation is interpreted as the equilibration attempts of an organism as it interacts with its environment. These interactions are in turn organized. That is, they are constantly arranged, rearranged and integrated into what Piaget[14] calls schemas. Schemas are held to be repeatable psychological units or programs of intelligent action.

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11 *Ibid*.

12 Piaget and his associates have not been consistent in their indexing of stages.

13 Jean Piaget, *The Origins of Intelligence in Children*, New York, Norton, 1952, p. 6.

14 Jean Piaget, "Stages of Cognitive Development", Richard I. Evans, (ed.), *Jean Piaget, The Man and His Ideas*, New York, Dutton, 1973, p. 18.

Piaget[15] further subdivides adaptation into two complementary and invariant processes — assimilation and accommodation. Assimilation involves the functions necessary to incorporate the data from experiences with the environment into the organism's present schemas. Accommodation includes the alterations and adjustments in the schemas made in response to the environmental demands that occur during interaction. Since every intellectual adaptation involves both assimilation and accommodation, equilibrium occurs when some sort of dynamic balance is struck between these two complementary mechanisms.

When an imbalance occurs in an organism, it attempts to change its schemas or to accommodate in order to adapt. In the adaptation, the organism with its store of schemas also attempts to embody the interaction in terms of these schemas, so assimilation is said to operate. Any unsuccessful assimilation attempts which produce a predominance of accommodation functions result in a disequilibrium which in turn causes new schemas to emerge. Piaget thus interprets cognitive development as the series of equilibration processes triggered by states of disequilibrium. He postulates stages as particular sets of schemas in some sort of equilibration state. The stages are

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15 Piaget, Op. Cit., 1952, p. 6.

hierarchically organized so that preceding stages are coordinated and integrated into the next higher stage[16]. When compared, these stages reveal qualitatively different clusters of schemas or structures. When the clusters within a stage are analyzed different structures also become apparent. But these structures, in turn, form integrated and interdependent wholes[17] or structures d'ensemble which can be used to account for diverse and apparently unrelated behaviour. Piaget[18] maintains that these structures d'ensemble develop contemporaneously.

Piaget also asserts that

> An operational system [a series of mental acts] derives its content from a series of abstractions of the subject's actions and not from particular features or properties of object [sic]. But this process of abstraction can be encouraged or obstructed by the material conditions in which the various groups of objects are encountered.[19]

Thus although a child apparently possesses a given competency in one situation, in a different situation which seemingly requires the same competency or which is structurally equivalent, it may appear that he now lacks

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16 Jean Piaget, The Child and Reality, p. 10-11.

17 Piaget, Op. Cit., 1952, p. 10.

18 Piaget, The Child and Reality, p. 21.

19 Jean Piaget and Barbel Inhelder, The Child's Conception of Space, London, Routledge and Kegan Paul, 1967, p. 484.

that ability. Piaget labels such a performance vacillation a horizontal _decalage_[20].

The evolving schemas, the invariant functions, the _structures d'ensemble_, Piaget concludes, reveal an evolution of knowledge. This evolution which begins as action on objects (physical experience) continues because an organism's experiences are organized and combined by logical abstraction into more elaborate spatio-temporal and logico-mathematical structures.

One major focus of Piaget's work has been on how children develop logico-mathematical and spatio-temporal notions such as number, time and space. Piaget claims that children attain the ability to think logically about actions carried out on actual objects during the concrete operational stage. Specifically they are able to conserve number, length, height, substance, weight and area. This means that children become progressively less reliant on perceptually misleading cues caused by an emphasis, a change or a transformation of some irrelevant factor and more reliant on the logic of the situation[21]. This logic involves the use of one or more of the following: 1) mentally undoing a completed action (reversibility); 2) recognizing that nothing has been added

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20 Piaget, _The Child and Reality_, p. 53.

21 _Ibid._, p. 6.

or taken away (identity); 3) being able to see the proportional effect of one factor on another (compensation). By applying one or a combination of these forms of logic, children then become able to conclude that a given quantity has remained constant in spite of certain transformations. The conservation descriptions which Piaget has formulated were generated from data which he collected during clinical questioning procedures (methode clinique)[22]. Basically this procedure involved the transformation of one of a pair of identical objects followed by a free conversation with the child about a relationship which remained constant in spite of the transformation. During these free conversations, Piaget attempted to follow the leads provided by the child's spontaneous answers; that is, answers reasoned by the child for the first time using "original material (previous knowledge, mental images, motor schemas, [...] etc.) and original logical instruments (methods of reasoning, natural tendencies of mind, intellectual habits, etc.)"[23] or which the child had already formulated during some other original reflection.

To determine which of the spontaneous replies were pertinent and from which stage descriptions could be evolved

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22 Jean Piaget, The Child's Conception of the World, St. Albans, Paladin, 1973, p. 13-41.

23 Ibid., p. 22.

Piaget[24] claims that he used the following guidelines:

1. A uniformity of answers given by children of the same average age was sought.

2. The ideas forwarded by the children had to reveal a continuous evolution with increasing age.

3. The ideas could not suddenly disappear but had to appear connected with or as a compromise between themselves and those new ideas attempting to supplant them.

4. The new ideas had to resist change or extinction through countersuggestion.

5. The new ideas had to influence neighbouring conceptions. To establish the stage where the structure of the new idea could be considered present in a logically coherent form, Piaget[25] asserts that he applied a pass rate of seventy-five per cent of the children tested.

To summarize, Piaget views the growth of intelligence as the attempts of an organism to achieve states of equilibrium. Intelligence is revealed in maximally adaptive behaviour. These adaptations occur because of maturation, social interaction, physical experience, but most

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24 *Ibid.*, p. 41

25 Jean Piaget, *Judgment and Reasoning in the Child*, New York, Kegan, Paul, Trench, Trubner, 1928, p. 23.

importantly because of equilibrations. Adaptations through equilibrations between assimilation and accommodation, Piaget contends, can be categorized into four main stages — the sensori-motor, the preoperational, the concrete operational and the formal operational. Although a stage forms an interdependent whole, each of the stages are qualitatively different from one another. Their evolution is hierarchical and reveals a growth of logic. Piaget has traced the logico-mathematical and spatio-temporal development of children as they react to such situations as space, time, and causality. Specifically, Piaget has analyzed children's responses when they were asked to conserve number, length, height, substance, weight and area. Such conservation ability, Piaget maintains, is achieved during the concrete operational stage where the application of reversibility, identity or compensation arguments becomes possible. Piaget derived his conservation descriptions for the concrete operational stage from analyses of spontaneous responses made during his clinical examinations. During one of his clinical investigations, Piaget traced the attainment of area conservation and this attainment is discussed in the following section.

2. Piaget's Interpretations of Area Conservation Development in Children.

One aspect of spatio-temporal development which Piaget has traced is the child's mental construction of Euclidean space. That is, how considerations and relationships among rigid spatial figures are attained. To assess how these notions are acquired, Piaget formulated and conducted experiments to test for the presence of ideas such as distance, length, rectilinear coordinates, volume and area. During one series of experiments, Piaget tried to determine how children acquire the notions necessary to judge how much surface remained when a portion of that surface was covered up. This experiment and Piaget's analysis of it are described in the first part of this section. In the next subsection, the evolution of this ability to remove and judge the remaining area is traced. Finally, empirical support is reported for Piaget's proposals for area conservation attainment.

During one series of spatio-temporal tests, Piaget[26] attempted to trace the growth of children's ability to recognize the quantitative equality of two areas which were originally congruent but from which two equal but differently

26 Jean Piaget, Barbel Inhelder and Alina Szeminska, The Child's Conception of Geometry, London, Routledge and Kegan Paul, 1960, p. 260-273.

positioned sub-areas were subsequently removed. A child who correctly concluded that the remaining areas were quantitatively equivalent and could substantiate his answer logically was considered by Piaget to be an area conserver. That is, the child was able to recognize that amounts remained invariant in spite of position or shape differences.

Specifically, Piaget analyzed children's responses in the following problem situation. Two identical green sheets of cardboard, each twenty by thirty centimetres, were presented to each child and he was asked to imagine that these pieces of paper were fields of grass. After a story about two cows that were to eat grass from their respective fields and a placement of identical models of cows beside each field, the subject was asked to compare the two fields to determine their equality. Then a wooden model of a building selected from a pile of equal sized models each measuring one by two centimetres was placed on one field. The experimenter continued with the story about one of the farmers who wanted to build a farmhouse on his field. After the farmhouse was positioned, the subject was asked whether the two cows would have the same amount of grass to eat or whether one cow would have more and to indicate the appropriate field. After the subject answered, the experimenter took another building from the pile and the subject was asked to compare this model to the building on the first field to determine their equality. Next the two buildings were simultaneously placed in identical positions, one on each field, and the subject was asked to determine whether the two cows had the same or different amounts of grass to eat. Then the position of one of the buildings was changed and the question about the equality or difference in the amounts of grass that each of the cows would have left to eat was repeated. The equality or difference in the amounts of grass which each cow would have left to eat will be subsequently referred to as the grass remaining question. Each following subsection in the test involved simultaneously adding one more building to each field. At times the buildings were placed in the same positions on each of the fields and then the grass remaining question was asked. The houses were then spread on one field and left abutting on the other field (see Figure 1) and the grass remaining question was reiterated. At other times, only the latter positioning of houses and questioning was used. The placement of buildings and questioning continued until either the child began to claim an inequality in the amount of grass one cow had left to eat in several succeeding subsections, or until there was a maximum of twenty farmhouses on each field.

The major stages and substages that Piaget reports along with the approximate ages at which the stages appear

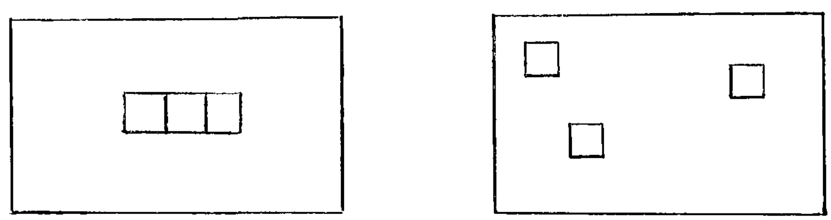

Figure 1. - The Cows in the Field Area Conservation Task.

Jean Piaget, Barbel Inhelder and Alina Szeminska, <u>The Child's Conception of Geometry</u>, London, Routledge and Kegan Paul, 1960, p. 262-264.

for the "Cows in the Field Test" (CIFT) are outlined in Table I. These stages and substages reflect the development of one phase of area conservation.

According to Piaget[27], the CIFT Stages I and IIA reveal the growth of one thought phase within the macroscopic stage of intuitive preoperational thinking. Stage IIB is transitional between intuitive preoperational and concrete operational thought while Stage IIIA is attained during the concrete operational stage.

Piaget also presents the following results and conclusions for CIFT area conservation. Every CIFT Stage I child, when there was one building on one field and none on the other, or one building on each field in identical positions, was able to recognize the inequality or equality of the remaining grass. To Piaget, this meant that the children were able to apply some form of abstraction, that is, to dissociate parts of the display such as space occupied by the building and the field. He also concludes that "the necessary character of Euclid's axiom seems to be evident at all ages"[28]. That is, children were able to apply a line of thinking, albeit an elementary and incomplete form, such as the following. If two green fields B and C are

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27 *Ibid.*, p. 270.

28 *Ibid.*, p. 263.

Table I.

The Piagetian Stages Describing the Development of the Cows in the Field Form of Area Conservation.

Stage	Approximate Ages	Addition and Subtraction of Equal Parts
I	below 5½ years	Not enough interest to pursue enquiry.
IIA	5½ to 6 years	Claims inequality of remaining areas after equal areas in different orientations have been removed.
IIB	6 to 7½ years	Range of intermediate responses until perception overwhelms the child.
IIIA	7½ to 8 years	Operational conservation.

Jean Piaget, Barbel Inhelder and Alina Szeminska, <u>The Child's Conception of Geometry</u>, London, Routledge and Kegan Paul, 1960, p. 261-273.

congruent, then the two area measures m(B) and m(C) are equal and m(B) = m(C). Since all of the buildings to be placed on the field are congruent and have the same face placed down (D), then the measure of the site occupied by each house m(D) is identical. To distinguish between those faces of buildings placed down on B and those placed down on C, one can designate $m(D_B)$ as the area occupied by the site of each building on field B and $m(D_C)$ as the area occupied by the site of each building on field C. Then according to the Euclidean axiom, if the same number of farmhouses (n) are placed on each field, then $m(B)-n[m(D_B)] = m(C)-n[m(D_C)]$[29]. Since n was not the same for each field, when only one building was in field B, the children logically concluded that the fields did not contain the same amount of grass to eat. The children also were able to make correct judgments when n=1 and the building positions were identical. Either during this subsection of the CIFT or shortly thereafter, Piaget reports that further testing became difficult or impossible as the children seemed to lose interest.

The ability to recognize identity by applying the Euclidean axiom improved for the CIFT Stage IIA children. Here children were able to recognize, according to Piaget, not only the initial inequality but also the equality of

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29 Ibid., p. 265-266.

the remaining grass areas when the same number of buildings in the same position was placed on each field. For some children this ability to identify that the amount of grass left to eat was identical even extended to the spread and abutting building arrangements but only when n was small; that is, when n = 1, 2, 3, 4. Piaget[30] attributes this ability to make a correct judgment to the child's ability to evoke a static image, to the ability to ignore the perceptual and misleading characteristics of the display but only to a certain point. So the factors that are perceptually unlike in the displays; namely, different perimeters, different congruencies, different positions, were disregarded and a correct sequence of operations or mental acts was undertaken but only within rather narrow limits. Piaget labels such an ability to sequence mental acts correctly as an elementary or infant form of composition. The ability to apply composition, but only up to a critical point, he labels simple intuitive composition. Children in Stage IIA possessed simple intuitive composition which could be misled by perception when the numbers of buildings were larger.

Simple intuitive composition became for children in Stage IIB of the CIFT articulated, intuitive compositions,

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30 *Ibid.*, p. 266-267.

according to Piaget[31]. That is, the children recognized the equality of the remaining grass when the number of buildings was larger, when n = 1, 2, 3, 4 ... 20, but denied equality after these critical points or vacillated as the numbers increased beyond this critical point. Piaget maintains that this ability to ignore the perceptual appearances and apply the correct composition, only to succumb to perception when the numbers or the positions of the buildings were overwhelming, revealed an inability to apply the Euclidean axiom generally as well as a lack of mobility and applicability of logical thought.

It was only in Stage IIIA that Piaget[32] infers the presence of operational composition where perceptual evaluation had been replaced by the correct application in all cases of the following operations: the areas forming subtrahends, $n[m(D_B)]$ and $n[m(D_C)]$ were grouped together and the appropriate sum taken from the appropriate minuends $m(B)$ and $m(C)$ to conclude correctly that $m(B) - n[m(D_B)]$ and $m(C) - n[m(D_C)]$ were equal if n was the same for both fields. The above processes, Piaget noted, could be shortened if the subjects recognized that by merely grouping the partial areas and comparing the numbers of buildings in

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31 Ibid., p. 271-272.

32 Ibid., p. 271.

each field, they could determine the grass area that was left to eat. Both the extended and the shortened method, however, implied that the subjects recognized a mutual compensation. That is, if the spread buildings occupied a given site but were mentally grouped together by reversible thinking, the space vacated would be mutually offset by the space newly occupied in the resulting arrangement. It is this kind of mobile, reversible and generalized composition that Piaget asserts characterizes the CIFT thinking attained during Stage IIIA.

In summary, to conserve area during the CIFT involves successive states of equilibration within a continuous equilibration process of adaptation and organization. Early attempts at area conservation involve the centration on one of two perceptual properties. That is, subjects focus on whether or not the buildings are together or spread out. Later, an alteration of focus on those properties is attempted. Finally a hesitant conjunction of these states occurs but not in all cases. It is not until a successive number of transformations occur that "a shift of conceptual focus from states to the transformations which lead from state to state"[33] is attained. These transformations involve such processes as a mental regrouping of the buildings and an appropriate removal of sub-areas before comparisons of the remaining sections are undertaken. According to Piaget, conservation with its rules of logic and reversibility depends on this kind of thought and occurs within a larger framework which is discussed next.

Piaget[34] also traced the general evolution of area conservation as a transition from topology, where relationships without size or shape considerations are made, to Euclidean notions, where spatial relationships of angles, straight lines and rigid figures are considered. Such a transition, Piaget concludes, is derived from the topological order property where only betweenness is considered and takes place when a child is able to coordinate several points of view and to construct projective straight lines by visually lining up several points while ignoring other reference lines. This development of projective straight lines is

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33 John H. Flavell, The Developmental Psychology of Jean Piaget, Toronto, Van Nostrand, 1963, p. 246.

34 Piaget, Inhelder and Szeminska, Op. Cit., p. 389-405.

followed by the conservation of parallels or affine relationships where the child recognizes parallel lines after a change in shape. Then the conservation of angles or similarity relationships develop where the ability to recognize congruent angles after a proportional size alteration of sides is attained. Thus Piaget summarizes,

> The construction of projective notions, affine relations and similarities paves the way for the subsequent elaboration of comprehensive coordinate systems which is implied by Euclidean space.[35]

More particularly, Piaget[36] describes the process and the mode of transition during the CIFT. Topologically, an area is "a portion of space bounded by a closed straight line"[37], and may be considered, depending on the order in which it is approached, as an area nested within larger and more inclusive members or, conversely, the relationship may be traced from larger, more encompassing enclosures to the more restricted form under consideration. These outward or inward sequences, however, require a notion of order, a notion of "nesting intervals, the relative sizes of which are given by enclosure"[38].

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35 Ibid., p. 390.

36 Ibid., p. 394-397.

37 Ibid., p. 394.

38 Ibid.

Piaget[39] maintains that children begin at the outside and proceed inwards, beginning at the boundary lines of the shape and working inwards when considering contained spaces. Such an evolution, Piaget contends, means that the limiting lines, the spatial containers, become something fixed or become reference terms. This process which occurs during the CIFT Stage IIIA contributes to a qualitative conservation of area.

Another characteristic which Piaget considers necessary for qualitative area conservation is the ability to recognize that areas can remain the same size in spite of position differences. That is, the child's topological or elastic view of space has evolved to a view of area as retaining a certain size after a position shift. This requires a recognition of fixed reference elements and a distinction between the fixed spatial container and a fixed but movable contained portion. When these abilities are coordinated then another ability necessary for qualitative area conservation has been attained.

The final constituent which Piaget claims is needed for qualitative area conservation during the CIFT is the ability to compensate for spaces newly occupied by those just vacated, or to recognize operationally change of

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39 Ibid., p. 395.

position. This requires the ability to coordinate a change in position with appropriate and referrent areas and then to apply the necessary compensations.

> This awareness of compensation rests on the discovery that parts of areas remain invariant when their position is changed. But that discovery in turn depends on the knowledge than when an object undergoes a [...] change of position the space left unoccupied [...] is exactly equivalent to space newly occupied.[40]

At this point, the argument becomes circular because compensation between space newly occupied and space just vacated depends on the ability to recognize size invariance in spite of position changes which in turn depends on a recognition of compensation. It is this sort of interdependent reasoning, however, which Piaget maintains enables the child to coordinate constituent operations, to conserve area qualitatively.

The reason Piaget[41] designates Stage IIIA of the CIFT as an operational but yet only a qualitative form of area conservation is that the child applies a reference system that is confined to those portions of space immediately adjacent to the item in question. This narrow application of reference systems, Piaget infers from another experiment where the areas of the fields themselves were

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40 <u>Ibid</u>.

41 <u>Ibid</u>., p. 396.

broken up and compared. From this experiment he concludes that the area of the fields themselves are conserved in Stage IIIB. Therefore during the CIFT Stage IIIA only the areas of the houses placed on the fields are conserved as they are viewed by the child as the "interior areas bounded by lines"[42]. Piaget[43] offers further support for this conclusion by reasoning that the buildings themselves are the only areas necessary for a logical compensation argument.

To summarize, the evolution of qualitative CIFT area conservation begins in topology and involves the recognition of enclosure, of an order that proceeds from limiting lines to the space contained as the lines themselves become fixed and become reference terms. Also necessary for qualitative area conservation during the CIFT is the ability to recognize that areas remain fixed after position change which in turn depends on the ability to compensate. Empirical support for the Piagetian descriptions of area conservation using the CIFT is discussed next.

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42 Ibid.

43 Ibid., p. 272.

The Cows in the Field Test was studied by Lovell and his associates[44]. One group of subjects used for this experiment ranged in age from five to nine years. There were ten five-year old subjects and fifteen subjects for each of the other age groups for a total of seventy children. As far as possible, subjects were chosen to represent all levels of ability. The experimenters used a uniform approach but asked supplementary questions if they felt such questioning was necessary. The findings for this group of English children broadly confirmed Piaget's CIFT stages.

Goodnow[45] also included the CIFT in her tests for conservation with a Hong Kong sample of 500 ten- to thirteen-year old boys from both Western and Chinese backgrounds. The sample was made up of four groups which were formed on the basis of the boys' education. This education ranged from full schooling to literacy only. Goodnow varied the CIFT procedure by placing twelve buildings, one at a time, on each field — scattered on one field and abutting on the other fields. If the subject denied equality of the

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44 K. Lovell, D. Kealey, and A. D. Rowland, "Growth of Some Geometrical Concepts", in Child Development, Vol. 33, 1962, p. 751-767.

45 Jacqueline J. Goodnow, "A Test of Milieu Effects With Some of Piaget's Tasks", in Psychological Monographs, Vol. 76-2, No. 36, Whole No. 555, 1962, p. 1-22.

remaining grass areas, one building was removed from each field, and the grass remaining question was asked again. This procedure was repeated until the subject claimed that the amount of grass that each cow had left to eat was the same in each field.

The data from Goodnow's Hong Kong study suggested that the task as arranged for this study was very difficult. Only about seventy per cent of the ten-year old children solved the task although the average age for mastery reported by Piaget and presented in Table I was approximately seven and a half years. When the performance of each group was determined, one sample group of boys of eleven, twelve and thirteen years of age performed most poorly. These boys attended schools in a low-income district or boys' clubs which were operated by Boys and Girls Club Associations. Here they were exposed to a nature study course which was taught from textbooks written in a language that was too difficult for them. Goodnow concluded that this course left the boys with the impression that the obvious answer was usually incorrect. Generally, however, for the other three groups, Goodnow reported that the order of stage appearance as reported by Piaget was supported.

In a three-year study of the evolution of nine Piagetian conservation skills, Dudek and Dyer[46] included the CIFT. The children's CIFT skill development supported Piaget's progression for the growth of operational thinking.

Taloumis[47] investigated the relationship between scores on Piagetian area conservation tasks and scores on tasks which Piaget claims require area measurement skills. Fixed sequences of subsections, three for area conservation and two for area measurement, were presented to eighty-four boys and eighty-four girls in grades one to three from twenty-one different classrooms in three schools. Taloumis found that the order of presentation did affect subsequent performance; that is, if area measurement tasks were presented first, area conservation scores were higher and vice versa. She attributed the increased scores to learning effects. She also found that measurement and conservation scores increased with age, but were not significantly different for boys and girls. Taloumis also reported that

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46 S. Z. Dudek and G. B. Dyer, A Longitudinal Study of Piaget's Developmental Stages and of the Concept of Regression, Washington, Educational Resources Information Center, United States National Institute of Education, 1969, p. 1-12, ED 043372.

47 Thalia Taloumis, The Relationship of Area Measurement as Affected by Sequence of Presentation of Piagetian Area Tasks in Grades One Through Three, unpublished doctoral thesis presented to New York University, New York, 1973, p. 1-20.

the greatest increase in area conservation scores did not occur at an earlier grade level than did the greatest increase in area measurement scores.

A somewhat different but related study was undertaken by Shantz and Sigel[48]. Thirty-six kindergarten children who could correctly identify but who nonetheless proved to be nonconservers of quantity, number and area were also tested for logical operations — multiple classification, multiple seriation, and reversibility. Following an assignment to one of two training groups, sessions which stressed identifying attributes of objects to discover simple classification rules or which focused on memorizing action sequences were undertaken. Neither training approach significantly affected the posttest conservation or logical operations scores. The only relationship determined was a significant but modest correlation ($\emptyset = .37$, $p < .05$) between area conservation and multiple classification. The authors interpreted this relation as providing

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48 Carolyn Uhlinger Shantz and Irving E. Sigel, Logical Operations and Concepts of Conservation in Children, Washington, Educational Resources Information Center, United States National Institute of Education, 1967, p. 1-79, ED 020010.

> [...] some support for Piaget's proposal based on a logical analysis that area conservation and classification skills are closely related in part-whole problems -- spatial part-whole in the case of area and logical part-whole in the case of classification.[49]

In general, research seems to substantiate the development which Piaget describes for the CIFT form of area conservation. The concepts that he has isolated as components for the CIFT form of area conservation seem to develop with age, and in the order he predicts.

3. Flavell and Wohlwill's Model of Cognitive Development.

As already outlined, Piaget posits distinct, general and task-related stages to trace intellectual development. This development, he asserts, depends on the simultaneous growth of the necessary spatio-temporal and logico-mathematical structures. Flavell and Wohlwill[50] are not so certain that these structures develop simultaneously. They account for cognitive development by extending and elaborating the notions underlying the development and consolidation of structures or mental programs within a single domain and attribute any inter-situational variability to the

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49 Ibid., p. 40.

50 Flavell and Wohlwill, Op. Cit., p. 67-120.

differences in the difficulty of the task. A summary of Flavell and Wohlwill's model is presented next.

In their model, Flavell and Wohlwill propose two interdependent developmental aspects to account for the cognitive process: the formal and the functional. The formal or competence portion of the model defines "the sort of cognitive entities that make up the successive outputs of development and how these entities are temporally, causally, and otherwise related"[51]. The functional or automaton part of the model defines the

> [...] activities or processes of the organism somehow specified in relation to environmental inputs by which it in fact makes the cognitive progress that has been formally characterized.[52]

Thus the formal portion of the model reflects attempts at logical and abstract representations of what the organism could achieve in an ideal environment while the functional section reflects attempts at portraying the underlying mechanisms which the organism uses to transform task cues into suitably coded form as well as how such information is stored, retrieved and used.

Both portions of their model, Flavell and Wohlwill[53] contend, will be complex. And currently, much of what fits

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51 Ibid., p. 67.

52 Ibid., p. 68.

53 Ibid., p. 74.

into each section must still be ascertained. The authors envision the descriptions of the formal portions as long and complicated while the functional aspects will be at least as structurally and functionally intricate as the most imaginative and powerful computer one can presently conjure. Continuing with the computer analogy, Flavell and Wohlwill characterize intellectual growth as basically a matter of developmental change in the content and organization of highly complex

> [...] 'programs', the nature of each program strictly determining what gets inputted from the environment (and from memory storage within the child) and how that input gets dealt with intellectually.[54]

The program contents and characteristics as presently defined, Flavell and Wohlwill[55] note, are also very inadequate, only crudely taxonomic and should not be considered as a complete organizational scheme. Flavell and Wohlwill caution that what they do list is merely suggestive of the kinds of items and characteristics that should be included. Some of these should be: 1) a large, and difficult to define but very important category of fundamental concepts and rules of the child's own self- and world-image and how these are derived through logic; 2) how

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54 Ibid.

55 Ibid., p. 74-75.

this information is represented and organized; 3) the course that a child is likely to pursue as the innate or presently incoming data are being extracted, processed, and used.

Flavell and Wohlwill[56] also recognize that a model depicting cognitive development must reflect the kind of development that improves with age, the kind of growth which when qualitatively analyzed reveals distinguishable phases. That is, qualitative growth is assumed to occur because some changes do occur in the kinds of processes that a child uses as he matures. Quantitative changes within the phases, they postulate, occur as the "operational efficiency, flexibility, mobility"[57] of the constituent skills improve. Thus, Flavell and Wohlwill speculate, the two kinds of changes — quantitative and qualitative — could temporally alternate or as they interpret Piaget's assimilation-accommodation-equilibration model of cognitive development, quantitative change at a lower stage may be a prerequisite for qualitative change at a higher stage.

In regard to the rate at which cognitive acquisitions occur, Flavell and Wohlwill[58] advance the notion that structural evolution proceeds gradually and that the rate

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56 Ibid., p. 77-78.

57 Ibid., p. 78.

58 Ibid., p. 79-80.

of development should be measured on a continuum that begins at the first appearance of a given structure and progresses until the given structure is generally available.

How does the transition between phases occur? Flavell and Wohlwill[59] conclude that at present no clear answer is available. They go on to suggest that perhaps the current definitions of competencies are really definitions of constituent subunit integrations. If the subunits were considered separately, each one might appear rather abruptly over an extended time period and their integration occur just as suddenly. But if the evolution of each subunit were to be treated individually, then the development until integration could be considered gradual. That is, changes which on the surface appear to be abrupt may in fact be the product of gradually acquired antecedents.

Flavell and Wohlwill[60] also argue that currently it is difficult to determine the correct sequence of concept acquisition. They attribute this to two conditions: 1) the incomplete identification of all of the important components necessary for cognitive development; 2) the inability of available measurement techniques to control for variables

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59 Ibid., p. 80.

60 Ibid., p. 82.

when variant or invariant sequences are being determined. Preliminary analyses, therefore, they recommend, should be concerned with the following four functional and logical relationships possible between cognitive components: 1) none or remote; 2) substitution; 3) implicative mediation; 4) nonimplicative mediation[61].

1. The none or remote relationship refers to concepts which are considered distantly related, or completely unrelated. These concepts, they speculate, may be acquired in any of the three temporal sequences possible — variant, invariant or synchronous.

2. Substitution occurs when one type of solution is simply replaced by another distinctly different kind of solution. As to whether the evolution of the substitution pairs is invariant for all individuals, Flavell and Wohlwill are uncertain. They suggest, however, that a weak invariant acquisitional sequence is probably most likely.

3. Implicative mediation can be inferred from behaviour which requires the reenactment of a simpler but necessary subskill. Here obviously the order of attainment is invariant.

4. The fourth possible kind of logical relationship between cognitive factors is nonimplicative mediation where

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61 Ibid., p. 83-90.

an already attained competency helps to develop some subsequent skill or ability. The first appearance of either aptitude is possible as well as the simultaneous and independent development of either one.

Although the results of research directed at ascertaining the order of concept attainment should ultimately determine the attainment order of the phases that characterize cognitive development, Flavell and Wohlwill[62] argue for the primacy of implicative and non-implicative mediations. These, they hypothesize, will probably provide the most fruitful returns for concept attainment research, with substitution probably reflecting the progress made as the child interacts with his environment. They draw this conclusion from the following premises. If concept, rule or ability B substitutes for some other concept, rule or ability A, A does not account for or explain B. Therefore something intermediate, something that constructs or mediates between A and B, must be sought. This intermediary form will probably be some type of mediation, they submit.

As to what should constitute the competence description within phases, Flavell and Wohlwill[63] are

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62 Ibid., p. 90.

63 Ibid., p. 93.

currently unable to give complete details. They subscribe, however, to the use of structural terms which describe rules, operations and programs which subsume the specific behaviour elicited. Such descriptions would not only allow a conceptualization of children's behaviour, but would also provide the benchmarks successively approximated in the process of cognitive development.

According to Flavell and Wohlwill[64], the structures so described must be traced individually so that their developmental timetables can be ascertained. If a child possesses a basic structure which he can apply to a variety of structurally equivalent tasks, then intertask consistency could be discovered. Flavell and Wohlwill[65] claim that any discrepancies so revealed can be accounted for by the functional portion of their model where the coding and information processing mechanisms are described.

Flavell and Wohlwill[66] also maintain that research directed at determining the growth of the intellect should be concentrated on a period they label transitional. They forward the following arguments to substantiate their position. Returns from research with children who do not

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64 *Ibid.*, p. 95.

65 *Ibid.*, p. 96.

66 *Ibid.*, p. 94.

possess a given competency are minimal since failure for these children when attempting tasks which require these operations is almost a foregone conclusion. Little information is also available from research conducted with children who possess the given competency because success can be predicted in almost every instance. So it is between these two phases, in the transitional phases, that inconsistent responses can be expected.

> For it is precisely during this period in which the newly-emerging structures are in the process of formation that the child's responses may be expected to oscillate from one occasion to the next, to be maximally susceptible to task variables, and accordingly to evince a relative absence of consistency.[67]

Thus, Flavell and Wohlwill[68] hypothesize that three parameters jointly determine a child's performance during a task. That is, if (P_a) represents the probability that a given function will be operative in a given child; if (P_b) is the coefficient which applies to the given task or problem and which determines whether the information will be appropriately coded and processed, if the necessary function is operational; and if (k) is a parameter which reflects the weight to be attached to the (P_b) factor for a particular child; then (P_a) and (k) quantitatively characterize a

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67 *Ibid.*, p. 95.

68 *Ibid.*, p. 98.

given child at a particular age level, while (P_b) represents the difficulty of the task. To clarify still further, each one of the foregoing elements will be examined in the three paragraphs which follow.

(P_a) is meant to reflect the probability that a given function in a given child is fully developed. Flavell and Wohlwill argue that an estimated probability for this factor is appropriate because during the transitional phases the required thought structures at times are apparent, at other times appear absent; therefore their occurrence is probabilistic. These variations can then be assigned values which range from zero to one. A value of zero can be assigned when the child indicates that he does not possess a given function while a value of one can be assigned when he demonstrates that he possesses a fully operational function.

(P_b) varies with the difficulty of the task and denotes the probability that for a given task the function, if operational, will be applied and produce the desired result. This parameter will range from zero to one,

> [...] depending on a host of factors related to task difficulty: the stimulus materials and their familiarity; the manner of presentation of the relevant information and the amount of irrelevant information from which it has to be abstracted; the sheer magnitude of the information load placed on the child in dealing with the problem; the role played by memory and sequential processing of information.[69]

But the effects of these task-related factors depend on the age of the child. To take a case in point, for a five-year old child, the success probability for a task requiring the correct sequencing of twelve stimuli is much lower than it is for a task requiring the sequencing of two stimuli. To account for the effects of the age factor, Flavell and Wohlwill introduce (k), or more correctly its complement, (1-k), as the weight to be attached to (P_b). Thus (k) which is assigned a value close to zero when the required function first becomes apparent, rises to a high of one when the function is fully established. So as (k) increases, as the function is consolidated, then the influence of ($P_b^{(1-k)}$) decreases.

The resultant probability equation, [P(+)], which Flavell and Wohlwill have generated to account for the success of a particular child with a designated task which can vary in difficulty is [$P(+) = P_a \times P_b^{(1-k)}$][70].

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69 Ibid., p. 99.

70 Ibid., p. 100.

As the various estimated values of (P_a), (P_b) and (k) are inserted into the formula, Flavell and Wohlwill[71] distinguish four phases which reveal the growth of intellectual structure.

In Phase 1, because the child lacks the given function (P_a) = 0 and so [P(+)] is reduced to zero.

In Phase 2, or the transitional phase, the value of (P_a) increases slowly from zero to one, while the value of (k) remains at zero or close to it [(k) = 0]. Thus when (k) = 0 the effect of (P_b), the susceptibility to content and situational variables is maximal. The resulting probability of success is calculated by entering the appropriate estimates of (P_a) and (P_b) into [$P(+) = P_a \times P_b$]. Thus in the middle of this phase when (P_a) can be assumed to be about 0.5 and for a task of medium difficulty where (P_b) = 0.5, [P(+)] = .25. Such a low probability will be reflected in the child's oscillations between correct and incorrect responses. These oscillations also reveal the intermediary form of reasoning that the child now possesses, and his inclination to be strongly influenced by task-related factors.

During Phase 3, (P_a) = 1.0 and the function in question is stabilized and consolidated. The probability

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71 Ibid., p. 100-104.

of success at the beginning of this phase will vary according to the difficulty of the task, (P_b). And because (k) also increases during this phase from zero to one, the effect of $(P_b^{(1-k)})$ decreases as it gradually approaches one.

In Phase 4, $(P_a) = 1.0$, $(k) = 1.0$, and so $[P(+)] = 1.0$. In this phase the given function is fully operational and the child is able to solve the given problem, regardless of the task related variables.

Flavell and Wohlwill[72] discuss the possibility that Phases 2 and 3 could be collapsed into one phase to reflect the concomitant changes in (P_a) and (k). They speculate that when research data becomes available this may be the view which will be most parsimonious. For the present, however, they forward the following reasons for retaining a separate Phase 2 and a separate Phase 3. By retaining a Phase 2 and a Phase 3, a conceptual clarity is maintained, and a distinction becomes possible between the time when a constituent functional unit is variably utilized and when it is applied correctly at all times.

To provide empirical support for their proposals, Flavell and Wohlwill have reanalyzed the data from the

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72 *Ibid.*, p. 101.

studies of Nassefat[73], Uzgiris[74], Glick and Wapner[75], and Lovell[76] in the light of their theoretical framework.

Nassefat's research centered on the transition from the Piagetian period of concrete operations to the formal operational period in 150 children ranging in age from nine to thirteen years. Some of the tests used in the study included probability problems, problems entailing lever principles, and volume conservation. The tests were separated into six domains and involved forty-eight items. The responses for each of the items were classified into different categories which ranged from the Pass-Fail type up to as many as twenty. Each item was also to be classified as Concrete (C) or Formal (F) depending on the kinds of operations necessary for its successful completion. Because of the ambiguities or inconsistencies found in the students' responses, roughly one-third of the items were

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73 M. Nassefat, Etudes quantitative sur evolution des operations intellectuelles, Neuchatel, Delachaux et Niestle, 1963, quoted by Flavell and Wohlwill, Op. Cit., p. 96-98.

74 Ina Uzgiris, "Situational Generality of Conservation", in Child Development, Vol. 35, No. 3, 1964, p. 831-842.

75 Joseph Glick and Seymour Wapner, "Development of Transitivity: Some Findings and Problems of Analysis", in Child Development, Vol. 39, No. 2, 1968, p. 621-635.

76 Kenneth Lovell, "A Follow-Up Study of Some of the Work of Piaget and Inhelder on the Child's Conception of Space", in the British Journal of Educational Psychology, Vol. 29, Part II, 1959, p. 104-119.

assigned to a third or an Intermediate (I) category. Subsequently the response categories for each item were combined and further reduced into a four-point ordinal scale[77]. This scale represented the different performance levels that were possible when the child separated relevant from irrelevant information combined with a Pass-Fail categorization of the inferences that he drew from the relevant data.

Among the various data analyses, Nassefat demonstrated the validity of the ordinal response scale as a measure of developmental level attained on a given item by calculating the association between response type and age level. He also analyzed the Guttman scalability of the Pass-Fail response items separately for each age level and for each of the C, I and F categories in terms of Green's Index of Consistency (GIC) and Loevinger's Index of Homogeneity. With the GIC, Nassefat found consistency basically "highest at an age level at which the discriminative power of each item category was maximal"[78]. That is, consistency was highest at age nine for the C items, at age eleven for the I items and at age twelve for the F items; although for F it never exceeded .25. Within their frame of

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77 Flavell and Wohlwill, Op. Cit., p. 96.

78 Ibid., p. 97.

reference, Flavell and Wohlwill interpreted this last low GIC as a mark of the incomplete elaboration of the operations generally associated with this age and this development stage.

The scalogram analysis[79] was also carried out to determine within each item domain its unitary dimensionality or its degree of homogeneity. The basic tenet underlying such an approach was that only as the requisite mental structures for each set of items were gradually acquired would such a dimensionality become apparent. So within each item domain, the progressive homogenization could be interpreted as one sign of the development of stage stability. Specifically, this occurred at age nine, the youngest age included in the study, for the C items — a finding consistent with the Piagetian framework of concept attainment. The low GIC for F items even at age thirteen was consistent with the Piagetian description of the formal operational stage which is estimated to become generally stable at fifteen years of age. And since the oldest age group included in the study was thirteen, it was concluded that the stabilization was still incomplete for most of these children.

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79 Ibid.

Nassefat also presented interrelations between responses and category items in support of the idea that performance across formally equivalent tasks becomes more uniform during the transition periods. Although Flavell and Wohlwill contend that serious statistical difficulties surround Nassefat's scalability and correlational analyses they still concluded that "if the data were taken at face value"[80], it supported their descriptions of stage-to-stage transitions.

Flavell and Wohlwill also interpret the research of Uzgiris as supporting their four phase model. During her attempts to verify the progressive attainment of substance, weight and volume conservations, Uzgiris also investigated the situational generality of conservation responses using different concrete materials, namely plastic balls, sets of cube-shaped nuts, wire coils and strands of plastic-covered wire. Each of the materials underwent three transformations for each of the substance, weight, and volume conservations for each child in the sample. The sample consisted of twenty children from each of the first six grades beginning at Grade one.

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80 *Ibid.*, p. 98.

In the reanalysis of the Uzgiris' data, Flavell and Wohlwill[81] assigned a Pass-Fail to each of conservation-material-transformation responses. Each set of two correct responses for three transformations using a particular material was further collapsed to a pass. Since volume conservation proved to be difficult for this sample and also since it could be interpreted as tapping formal operations, Flavell and Wohlwill continued only with an analysis of substance and weight conservation responses which required concrete operations. Flavell and Wohlwill developed five phases — Phases 1, 2, 2/3, 3, 4 — by assigning values to (P_a), (P_b), and (k). These estimates were based on the known appearance of substance before weight[82], on an assumed comparable difficulty level for all substance- or weight-material combinations, and on an estimated value for the growth of the various structures through the phases. Flavell and Wohlwill[83] found that if [P(+)] was calculated, the number of correct responses predicted and observed were reasonably close.

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81 Ibid., p. 114-118.

82 Jean Piaget, Op. Cit., 1968, p. 44-45.

83 Flavell and Wohlwill, Op. Cit., p. 117.

Flavell and Wohlwill[84] also proposed logically supported definitions for their expanded set of five phases. Each phase was made up of a combination of response patterns for each of the substance- and weight-conservation groupings. Then by sorting the actual responses by grade level and the phases they had defined, another development became apparent. In Grade one the children who were in Phase 1 predominated while in Grade two the greatest number of children were in Phase 2. For Phase 2/3 and 3, no clear pattern emerged, while Phase 4 children appeared in Grade three and up with the greatest number occurring in Grade six.

To provide further support for their model, Flavell and Wohlwill[85] counted the number of times within each substance- or weight-material combination that a child's answers' oscillated. That is, the number of times a child gave one or two correct answers. Oscillations were quite rare in Phase 1 and this Flavell and Wohlwill ascribe to the lack of the required competency where $(P_a) = 0$. Oscillations were also scarce in Phase 4 where $(P_a) = 1$; where success was almost guaranteed. The maximum number of oscillations occurred during Phase 2 because of the transitional nature

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84 Ibid., p. 115.

85 Ibid., p. 118.

of the phase. This supported their contention that during this phase the child is maximally susceptible to distractions connected to situational or content variables.

To corroborate their phase argument further, Flavell and Wohlwill[86] also point to the close resemblance between the Piagetian stages such as those which became evident during the CIFT and their phases. Piaget's Stages I, II, and IIIA closely match Phases 1, 2, and 3 respectively.

In support of their transitional phases, Flavell and Wohlwill[87] cite not only the work of Nassefat and Uzgiris but also the studies of Glick and Wapner[88] and Lovell[89]. Flavell and Wohlwill use these latter findings to substantiate their Phase 3, and also their claim that performance varies according to the differing information-processing demands of these tasks. Glick and Wapner investigated <u>decalages</u> or the inability to apply what seems to be the same basic process during an experiment in which children were asked to draw transitivity conclusions. That is, if A were shown less than B(A<B) and then B<C, did the ability to conclude that A<B<C appear at the same time or

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86 <u>Ibid</u>., p. 100-101.

87 <u>Ibid</u>., p. 102.

88 Glick and Wapner, <u>Op. Cit</u>., p. 621-635.

89 Lovell, <u>Op. Cit</u>., 1959, p. 104-119.

later than a similar judgment from an $A<B$, C is greater than B presentation? They found that the latter presentation resulted in a later appearance of the $A<B<C$ conclusion. Lovell produced another instance of a horizontal *decalage* when he demonstrated that children could copy from a necklace and produce a straight line of beads before they could copy from a model necklace in the shape of a figure eight.

More direct investigations of Flavell and Wohlwill's postulated transitional concepts during Piagetian classification and perspective tasks have been done by Overton and his associates. Overton, Wagner and Dolinsky[90] used three groups of thirty-two children (four-five-year olds, six-seven-year olds, and eight-nine-year olds) from middle and lower socioeconomic backgrounds. The children were asked to fill in an empty cell in a two-by-two matrix. One form involved the use of pictures while for the other, three dimensional items were used. No difference was found between the two forms but performance scores improved significantly across all three age levels for the middle socioeconomic group. For the lower social group, significant improvement occurred only between the four-five- and the six-seven-year old group. The eight-nine-year old

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90 Willis F. Overton, Janis Wagner and Harriet Dolinsky, "Social-Class Differences and Task Variables in the Development of Multiplicative Classification", in *Child Development*, Vol. 42, No. 6, 1971, p. 1951-1958.

lower socioeconomic group also performed significantly poorer than their middle class counterparts. Overton et al. attributed these poorer performances of the lower socio-economic eight-nine-year old children to a failure of their environment to orient them away from perceptual strategies. Consequently they speculated that although the necessary cognitive structures had been activated, they remained transitional for a longer period for children of lower socioeconomic status.

Brodzinsky, Jackson and Overton[91] studied the effect of situational variables on transitional children. Each of the two treatment groups, each containing thirty-six children and made up of equal sized groups of six-, eight-, and ten-year old children, was asked to predict perspectives of single and multiple arrays from different positions. For one treatment group, the stimulus arrays were in view during the entire testing procedure while the other group had the stimulus arrays shielded from them while they made their predictions. Shielding the stimulus arrays facilitated the performance of eight-year old children, considered in this experiment to be transitional, and to a lesser extent of

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91 David M. Brodzinsky, Joseph P. Jackson and Willis F. Overton, "Effects of Perceptual Shielding in the Development of Spatial Perspectives", in Child Development, Vol. 43, No. 3, 1972, p. 1041-1046.

the ten-year old children, but had no effect on the six-year old subjects. Brodzinsky *et al*. claim that the improvement during shielding was due to the elimination of distracting cues during the transitional period.

For a matrix-completion task, Overton and Brodzinsky[92] investigated the influence of task variables on performance. Thirty four-year old, thirty six-year old and thirty eight-year old children were subdivided into three treatment groups; the perceptual, the rule and the linear rule. The only significant findings were: 1) performance increased across the ages; 2) only the six-year old linear rule group where the perceptual cues were considered minimal performed better than the six-year old perceptual group. From this latter finding, Overton and Brodzinsky concluded that the functioning of operational structures of transitional children had been affected by task variables.

The foregoing studies seem to suggest that task variables do affect performance in some instances but that their influence is unclear. More research to determine under what circumstances, how and which task variables restrict performance seems necessary.

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92 Willis F. Overton and David M. Brodzinsky, "Perceptual and Logical Factors in the Development of Multiplicative Classification", in *Developmental Psychology*, Vol. 6, No. 1, 1972, p. 104-109.

Flavell and Wohlwill[93] also warn that certain restrictions must be imposed on the use of their model until it has been subjected to more research. Some of the limitations which they feel should be imposed include: 1) the model should only be used to account for horizontal _decalages_ within a single domain or across tasks which are structurally equivalent; 2) only the functional portion should be used to account for horizontal _decalages_; 3) the operational definition of task-related variables affecting performance is still not fully satisfactory or complete.

In summary, Flavell and Wohlwill have developed a model to account for intellectual growth. Full descriptions of the model do not exist at present. The characteristics included in the present model are: 1) an incremental feature to reflect increasing ability through maturation; 2) a qualitative and quantitative analysis of the growth into phases; 3) a restriction to single domains to trace growth from first appearance to general applicability of given structures. To account for transitions, Flavell and Wohlwill recommend analyses which focus on the four functional relationships of none or remote, substitution, implicative and nonimplicative relations. They also

93 Flavell and Wohlwill, _Op. Cit._, p. 103-104.

recommend research designed to determine intertask consistency within phases.

By postulating the formula $[P(+) = P_a \times P_b^{(1-k)}]$, Flavell and Wohlwill attribute a child's intellectual functioning to his competency abilities (P_a), the difficulty of the task (P_b) and a weighting factor (k) applied to (P_b) which varies with a child's ability to process and to code information appropriate to the given operation. As the estimated values for the various parameters are inserted into [P(+)] then a four phase development became apparent. As such, the phases could be used to trace the development or application of specific rules or operations with any horizontal decalages attributable to task variables. Some data reanalyses which Flavell and Wohlwill used to support their four phases were also described. Finally some more direct research was reported in which the effects of task variables on performance during experiments modelled on Piaget's conservation tasks were investigated. Thus, Flavell and Wohlwill's model of cognitive development is an account of formal and functional factors but within a Piagetian mold. The key differences and likenesses of the two models are discussed in the succeeding section.

4. A Comparison of Piaget's and Flavell and Wohlwill's Models.

Flavell and Wohlwill admit to being influenced by "the work of Jean Piaget [...] at every turn"[94], and that their model was generally fashioned within the Piagetian framework. They also assert, however, that their work is an attempt to extend and elaborate Piaget's ideas. The essential similarities and differences between the two models will be examined under four headings: the products of the cognitive process; acquisitional rate; the developmental sequences; the <u>structures d'ensemble</u>.

The Products of the Cognitive Process. Both Piaget[95] and Flavell and Wohlwill[96] generally define structures as the products of cognitive development. When the structures are being considered two possibilities suggest themselves. The structures can be viewed by the authors as differing quantitatively or qualitatively from one another. That is, the structures can vary in amount or degree when some dimension is considered.

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94 <u>Ibid</u>., p. 67.

95 Piaget, <u>Op. Cit</u>., 1968, p. 79-83.

96 Flavell and Wohlwill, <u>Op. Cit</u>., p. 67.

Piaget[97] maintains that qualitative differences exist when perception-based reasoning evident during the preoperational stage is compared to the inference-based reasoning that characterizes concrete operational responses. Flavell and Wohlwill[98] support such an interpretation but do so only tentatively. They withhold full endorsement pending analyses which investigate functional relationships. At the same time, Flavell and Wohlwill[99] recognize and incorporate into their model an increase in flexibility and generalizability of the cognitive process or a form of quantitative difference. As noted earlier, Flavell and Wohlwill interpret Piaget's assimilation-accommodation-equilibration model as suggesting that quantitative changes within lower stages pave the way for qualitative change. Thus quantitative and qualitative changes alternate. Essentially then, Piaget and Flavell and Wohlwill regard some increases in cognitive ability as qualitative while others are regarded as quantitative.

The Acquisitional Rate. Two possibilities also exist when the acquisitions of cognitive structures are

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97 Jean Piaget and Barbel Inhelder, The Psychology of the Child, New York, Basic Books, 1969, p. 99.

98 Flavell and Wohlwill, Op. Cit., p. 77.

99 Ibid., p. 78.

considered. The structures can be made to appear abruptly to be followed by a period of rapid intellectual growth or structural development can be made to appear gradual throughout.

For Piaget[100], the general availability of a particular cognitive ability signals the achievement of an equilibrated state. Descriptions of these states define the stages that he has postulated. Therefore, although the stages are qualitatively different, they reflect the end result of a progressive stabilization of schemas. So in one sense, the stages appear abruptly. In another sense, their evolution could be interpreted as gradual. This is the case in those situations where the period from the first appearance of an ability to its general availability is considered as evidence of the presence of that ability. Flavell and Wohlwill[101] subscribe to this latter position because at present they confess that they do not know enough to describe or state conclusively how competencies do first appear. What they speculate might happen is that ability subunits abruptly enter the cognitive system to be subsequently integrated. And that integration might effectively mask the fact that the subunits are in and of

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100 Piaget, <u>Op. Cit</u>., 1950, p. 7.

101 Flavell and Wohlwill, <u>Op. Cit</u>., p. 80.

themselves discrete. Cognitive abilities which are currently identifiable may well be the evidence of these successful integrations.

Developmental Sequence. It is when the structural sequence is considered that an important difference between Piaget's and Flavell and Wohlwill's positions becomes apparent.

Piaget[102] maintains that the sequence of intellectual development is invariant or fixed. According to him, higher stages integrate or incorporate previous or lower stages.

Flavell and Wohlwill[103], on the other hand, maintain that acquisitional sequences are difficult to ascertain because of the inadequacy of current measuring devices and the incomplete identification of constituent abilities. Therefore they recommend investigations of functional relationships between concepts. Such research would help clarify what Flavell and Wohlwill[104] have labelled substitution. That is, Piaget concluded that inference-based reasoning, such as that which occurs during Stage IIIA of the CIFT, replaces perception-dominated responses

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102 Piaget, The Child and Reality, p. 10.

103 Flavell and Wohlwill, Op. Cit., p. 82.

104 Ibid., p. 85.

of the previous stages. Flavell and Wohlwill[105] contend that further analyses and research of implicative relations to help identify possible mediators needs to be carried out in order to substantiate or reject Piaget's conclusions. It will be recalled that implicative relations to determine mediators refer to those factors which help relate or explain the acquisition or construction of a higher level ability from a lower one.

The Structures d'Ensemble. Similarities and differences also become apparent when Piaget's and Flavell and Wohlwill's interpretations regarding the relationships of structures within a stage are compared.

Piaget considers the appearance of generalizable and abstract structural wholes which develop simultaneously[106] and which are made up of interdependent units[107] as a necessary condition for a stage description. The gradual attainment of these wholes occurs because of a growth in logic. Flavell and Wohlwill[108] agree in part with such a growth in logic and provide for it by postulating a (P_a)

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105 Ibid., p. 90.

106 Piaget, The Child and Reality, p. 21.

107 Piaget, Op. Cit., 1952, p. 10.

108 Flavell and Wohlwill, Op. Cit., p. 99.

factor. What Flavell and Wohlwill[109] criticize is Piaget's contention that all of the various wholes develop at the same time. They base their criticisms on the following arguments. First, empirical data from experiments measuring the degree of success achieved by children attempting diverse but structurally equivalent tasks have not supported Piaget's system. Therefore, rather than trying to trace a simultaneous evolution of all units, from birth to adolescence, Flavell and Wohlwill recommend that separate structures or structures within a single domain in the transitional period be traced.

Secondly, Piaget emphasizes the developing reasoning process but does recognize that as these processes are undergoing consolidation[110] they are susceptible to task and situational variable influence to produce horizontal <u>decalages</u>. To Flavell and Wohlwill the latter "notions represent purely <u>ad hoc</u> constructs"[111]. To account for performance differentials more systematically and efficiently, they propose consideration of the mechanisms of coding and processing information. This, they contend,

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109 <u>Ibid</u>., p. 94-95.

110 Piaget and Inhelder, <u>Op. Cit</u>., p. 484.

111 Flavell and Wohlwill, <u>Op. Cit</u>., p. 95.

can be accounted for by the (P_b) portion of their model[112]. Then the total probability of success for a given task can be estimated if appropriate entries are made in the formula $[P(+) = P_a \times P_b^{(1-k)}]$[113].

To summarize, evidence of structures define intellectual growth for Piaget as well as for Flavell and Wohlwill. Both models provide for an alternation between quantitative and qualitative changes in structures. But where Piaget views the appearance of new structures as the abrupt realization of a developmental process, Flavell and Wohlwill recommend reinterpreting evidence for the existence of the stages from the time that a competency first becomes apparent. Then the integration of the sub-units which might enter the system abruptly might be evidenced. Further investigations are also recommended by Flavell and Wohlwill to determine if implicative relationships occur between factors currently labelled substitution. Finally where Piaget insists on the unitary development of _structures d'ensemble_, Flavell and Wohlwill urge further research to determine the validity of this conclusion. They suggest that research should concentrate on the horizontal _decalages_ which occur during the transitional

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112 _Ibid_., p. 99.

113 _Ibid_., p. 100.

period. The use of their formula [$P(+) = P_a \times P_b^{(1-k)}$] should help identify the task variables that produce performance oscillations.

One set of task variables which generally has been shown to affect performance[114] is the number of irrelevant and relevant attributes. This finding together with a recommendation by Brainerd and Allen[115] that more research needs to be done in the field of area conservation prompted an examination of the CIFT in an attempt to isolate the relevant and irrelevant attributes present.

5. Relevant and Irrelevant Attributes in Area Conservation Tasks.

Flavell and Wohlwill readily acknowledge that they are unable to provide a fully operational description of (P_b). This also becomes apparent when the assumptions which underlie information-processing are listed. These assumptions will be delineated in the first part of this section. This will be followed by a discussion of the role

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114 Herbert J. Klausmeier, Elizabeth Schwenn Ghatala, and Dorothy A. Frayer, Conceptual Learning and Development, A Cognitive View, New York, Academic Press, 1974, p. 51.

115 Charles J. Brainerd and Terry Walter Allen, "Experimental Inductions of the Conservation of 'First-Order' Quantitative Invariants", in the Psychological Bulletin, Vol. 75, No. 2, 1971, p. 142.

of irrelevant and relevant attributes during concept attainment and an analysis of the CIFT to ascertain its relevant and irrelevant attribute loadings.

The incomplete state of information processing theory becomes apparent when the assumptions underlying coding, attention and hypothesis testing are listed. These assumptions[116a] include:

1. The experimenter assumes that the subject possesses an analyzer for every stimulus used.

2. Analyzers which respond to particular features break up the stimulus pattern into its constituent parts.

3. Little attention is generally paid to enumerating the number of analyzers. A similar disregard of how many analyzers are engaged during a particular discrimination problem in prevalent.

4. During any single trial, only a portion of the total available number of analyzers is active.

Moreover, these assumptions and the research based on these assumptions become the basis for Klausmeier *et al.*[116b] when they describe their model of conceptual learning and development.

116a Tom Trabasso and Gordon H. Bower, *Attention in Learning Theory and Research*, New York, Wiley, 1968, p. 12-13.

116b Klausmeier, Schwenn Ghatala, and Frayer, *Op. Cit.* p. 34-54.

In another recent development, Klahr[116c] discusses the general features of a coding and hypothesis testing paradigm appropriate to Piagetian tasks. Basically he asserts, the paradigm should consist of "models of performance of the organism at two different levels of development"[116d] plus a model depicting the transition or the developmental mechanisms linking the two stages.

Klahr[116e] claims that he has generated running computer programs for specific conservation tasks. These programs constitute a model of the routines used to successfully complete a given Piagetian task. Klahr recognizes an inability to model the transition process and notes that:

> with respect to transition, until we have more precise models of what it is that is going through transition, our theories must remain vague and non-operational.[116f]

To describe the processes used by a child who successfully completes novel Piagetian tasks, Klahr claims two fundamental operations are necessary. These are:

116c David Klahr, "An Information-Processing Approach to the Study of Cognitive Development", Ann D. Pick (ed.) Minnesota Symposia on Child Psychology, Minneapolis, The University of Minnesota Press, 1973, p. 141-177.

116d Ibid., p. 141.

116e Ibid., p. 144.

116f Ibid., p. 145.

> First he [the child] must assemble, from his repertoire of fundamental processes, a task-specific routine that is sufficient to pass the task at hand; then he must execute that routine.[116g]

Failure to execute can be attributed to any of three causes:[116h] a lack of the necessary fundamental function; the inability of the assembler to integrate the appropriate fundamental functions, or failure to execute correctly the routines for the given task.

Even when requisite processes exist, failure to execute can be attributed either to that poorly-defined notion labelled lack of motivation or to the overwhelming processing demands of the task.

The theories and approaches described above may or may not be valid. For the time being, they appear to provide a useful frame of reference which is not without flaws. The major flaws detectable relate to the incompleteness of the functional descriptions and the transition processes developed. In spite of this, Flavell and Wohlwill take the position that task-related variables do influence

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116g _Ibid_., p. 149.

116h _Ibid_.

information-processing. The influence of these material factors listed in Section three then could be used to help account for horizontal decalages which occur when transitional children attempt conservation tasks.

One of the factors which Flavell and Wohlwill recognize affects information-processing is the number of irrelevant attributes from which the relevant information is to be abstracted. Any increase in the amount of irrelevant information, Klausmeier, Schwenn Ghatala and Frayer note produces a "retarding effect on concept identification performance"[117]. Klausmeier *et al.*[118] also point out that this is a highly reliable conclusion in the concept-learning literature.

Gelman[119] in analyzing a typical conservation task noted the presence of a large number of irrelevant attributes and the distraction which resulted from the emphasis of one of these attributes. From this she inferred that a high hypothesis load faced each subject during conventional Piagetian tasks.

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117 Klausmeier, Schwenn Ghatala, and Frayer, *Op. Cit.*, p. 51.

118 *Ibid.*, p. 208.

119 Rochel Gelman, "Conservation Acquisition: A Problem of Learning to Attend to Relevant Attributes", in the *Journal of Experimental Psychology*, Vol. 7, No. 2, 1969, p. 168-169.

Similar conditions are readily identifiable in traditional area conservation tasks. In the CIFT, a display of three-dimensional items is presented to the subject to assess the presence of a two-dimensional ability. Consequently, it seems reasonable to conclude that a number of irrelevant attributes are present. For example, when the objects representing the farmer's buildings are positioned, extraneous heights, widths, lengths as well as various faces, line segments, vertices, amounts of volume, various perimeters, various surfaces and amounts of surface are introduced. The green sheets of cardboard used to represent the fields possess a thickness no matter how thin the cardboard is and so a third dimension is also present here as well as most of the catalogue of irrelevant cues listed above for the buildings. Furthermore, although charming and intended as a means of maintaining interest and a certain familiarity with the underlying notions, the use of the cows, the fields and the grass is irrelevant when area concepts are being examined. Such a list of irrelevant characteristics was not compiled in order to be specious but merely to point out that it is precisely these irrelevancies which the adult automatically overrides when he is asked to judge the remaining area in a CIFT display; since such an overriding is a function of and a proof of the adult's operational status.

The mass of attributes which the foregoing non-exhaustive survey has uncovered would tend to suggest that Piaget had no sure way of knowing on which features the subject had focused in solving the area conservation problem. Also indeterminate was the notion of area which the child had derived from Piaget's communications. It is not impossible that the subject faced with the large complex of characteristics had focused on one of the "n" irrelevant factors or relations. Moreover, if the procedure which Piaget used involved spreading one set of buildings, it was very likely that the subject would centre on this distraction "since movement or change [...brings] attention to an attribute"[120].

Thus, to make a correct conservation judgment during the CIFT, the child had to identify the relationship supposedly defined by the experimenter. This meant that the subject had to reject any irrelevant attributes on which he had originally focused or any incorrect relationships which he had formed; and to continue to reject any misleading characteristics which had been stressed. Generally then the CIFT situation seems to require that the child see the problem through the eyes of the adult and at the same time separate the evidence presented to him by his senses. It is not unreasonable to conclude that the CIFT presented each

120 *Ibid.*, p. 169.

subject with a high hypothesis load. It is further suggested that the experimenter using the CIFT has no definite means of determining which of the many hypotheses the child is attempting to prove.

One method of reducing the number of irrelevant information and thereby the hypothesis load was suggested by Dwyer[121]. He noted that if the realism of representation was plotted on a continuum which ranged from the situation itself to a very abstract characterization of that situation, as the degree of abstraction increased, the amount of irrelevant information decreased.

Then as Klausmeier et al. assert:

> [...a] reduction of irrelevant information would make it more likely that a subject would attend to relevant characteristics of the concept, and therefore, test the correct hypothesis sooner.[122]

Gelman[123] also provides support for this prediction. After training children to pay attention to relevant features during length and number conservation tasks, she found that there was an almost 100 per cent improvement in the number of conservation responses made

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121 Francis M. Dwyer, Jr. "Adapting Visual Illustrations for Effective Learning", in the Harvard Educational Review, Vol. 37, No. 2, 1967, p. 252.

122 Klausmeier, Schwenn Ghatala, and Frayer, Op. Cit., p. 208.

123 Gelman, Op. Cit., p. 167.

during structurally equivalent length and number tasks. More importantly, she found that there was a sixty per cent increase in conservation responses in other more remotely related tasks such as mass and liquid. From this she concluded that "children fail to conserve because of inattention to relative quantitative relationships and attention to irrelevant features in classical conservation tasks"[124].

Indirect support for the earlier testing of hypotheses when the number of irrelevant stimuli has been minimized is also provided by Clark[125]. He cites forty studies which support and only one which does not support the view that concept attainment is facilitated in research settings when the number of noncritical properties has been reduced.

Direct attempts to minimize the number of irrelevant stimuli in the procedure used to test for the presence of area conservation are not reported because as

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124 *Ibid*.

125 D. Cecil Clark, "Teaching Concepts in the Classroom: A Set of Teaching Prescriptions Derived from Experimental Research", in the *Journal of Educational Psychology*, Vol. 62, No. 3, 1971, p. 258.

Brainerd and Allen[126] point out, there has been a paucity of area conservation research.

It is suggested that procedures such as those developed in the present research should help overcome some of the difficulties inherent in testing for area conservation. This result is expected for two reasons. The first is that a control over the number of stimuli presented was attempted. The second is that comprehensive protocols for the administration of the tests based on the CIFT were followed. These controls and procedures are described fully in the following chapter.

To recapitulate, Flavell and Wohlwill account for the task variable influence by postulating the factor (P_b). One such task variable is the number of irrelevant attributes from which the pertinent information must be extracted. This factor influences performance by affecting the hypothesis load of the subject. An analysis of the CIFT revealed the presence of a large number of irrelevant features and a poorly controlled presentation of these attributes. Consequently it was concluded that the effect of these non-critical factors on the child was not clearly understood. By using a more abstract form of the representational items used in a series of tests based on the CIFT, it was

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126 Brainerd and Allen, Op. Cit., p. 130.

postulated that the number of attributes could be reduced and the hypothesis load consequently lightened. If the favourable circumstances just described could be actualized then perhaps new insights into the way children attain area conservation would be obtained. Of equal importance would be the opportunity provided for the resolution of the basic conflicts existing between the explanations of concept attainment advanced by Piaget and those advanced by Flavell and Wohlwill.

6. The Problem and Research Hypothesis.

On the basis of the foregoing discussion it is postulated that during a uniformly administered area conservation test, children in the transitional stage will give the greatest number of conservation responses when the number of irrelevant attributes is least. Specific hypotheses derived from this postulate are elaborated in Chapter II. These hypotheses should provide an answer to the question, to what extent do the number of irrelevant attributes affect the ability of transitional children to conserve area?

CHAPTER II

EXPERIMENTAL DESIGN

The experimental design is detailed in this chapter. The procedures used to manipulate the number of irrelevant attributes and the method used to measure the area conservation responses are discussed in the first section. In the second section, the subjects used in the present study are described. The experimental methods followed are outlined in the third section. The statistical techniques used in analyzing the results are presented in the fourth section.

1. The Green Space Tests.

To allow both the manipulation of irrelevant attributes and the measurement of conservation responses when children applied the Euclidean axiom to area, three forms of a Green Space Test (GST) were developed. In the first part of this section, the factors considered in determining the GST format are elaborated. Then procedures used to vary the number of irrelevant characteristics among the three GST forms are specified. Finally the basic GST format and scoring procedures are described.

Considerations Underlying the Green Space Test. As noted earlier, Piaget used the clinical method while he was testing and from time to time felt free to change whatever aspect of the testing situation he deemed necessary. A basic tenet underlying the development of the GST was the use of a uniform format so that consistent procedures, questions, sequences, and scoring could be followed. This would also permit certain statistical analyses to be employed.

Two other considerations were held to be important during the development of the GST. First, in keeping with Flavell and Wohlwill's recommendations the GST had to be restricted to one domain to assess how task variables influence the conservation responses in that domain. Second, the GST had to be a clear derivative of Piaget's CIFT.

To accommodate this last consideration, some Piagetian ideas were used unaltered while others were slightly modified before being incorporated into the GST. The basic similarities and modifications will be discussed simultaneously.

Green regions much like the fields Piaget used in the CIFT were included in the GST. But instead of using two pieces of green cardboard as Piaget did, two green acetate sheets were used throughout the GST. This allowed a consistent use of the green region idea in all three GST forms.

Where Piaget used buildings on fields during the CIFT, appropriate regular objects such as cubes and squares were placed on the green regions in each GST form. In addition, all the objects positioned on the green regions appeared black in colour.

Conditions which Piaget[1] claimed gave rise to non-conservation responses were also included in each of the GST forms. That is, equal numbers of objects were placed on the green regions, but spread on one and abutting on the other.

Other factors that influenced the development of the test forms for the present research included the following. As discussed in the previous chapter, during the CIFT, many irrelevant attributes were present. These were: 1) use of a situation which included notions that the child could misconstrue or misinterpret; 2) use of an idea that the experimenter would have difficulty in communicating to the subject; 3) movement of objects to emphasize irrelevant features. Each of these will be examined in turn.

During a previous administration of the CIFT in which the investigator was involved, urban children seemed to have difficulty with the idea of a cow eating grass in a field. While this matter was never directly investigated,

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1 Jean Piaget, Barbel Inhelder and Alina Sziminska, The Child's Conception of Geometry, London, Routledge, Kegan and Paul, 1960, p. 273.

it was attributed to the children's lack of experience with such a nonurban situation.

Another problem which accompanied the use of the CIFT was the introduction of what Hovland has labelled Error Factor Producers which he defined as "factors not intended to be relevant by E [...] but selected as possibilities by the S"[2]. During the CIFT, one of the possible Error Factor Producers was the grass that the child was asked to imagine. First it was difficult to ascertain what the child had imagined. Secondly, if the child judged that the same amount of grass existed in both fields, had he considered, considered and rejected, or been completely unaware of the following logical possibilities? Was the grass imagined equally tall, equally dense on the two fields? Were any inequality judgments made because of these considerations? In either instance, if the children drew conclusions on the basis of height or density concepts then as Piaget[3] pointed out, the responses would in reality reflect substance or volume conservation and not area conservation. Hovland[4] also remarked that subjects who are

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2 Carl I. Hovland, "A 'Communication Analysis' of Concept Learning", in the Psychological Review, Vol. 59, No. 6, 1952, p. 462.

3 Piaget, Inhelder and Szeminska, Op. Cit., p. 274.

4 Hovland, Op. Cit., p. 462.

most imaginative are often penalized because they have considered such unintended possibilities.

Furthermore, although Piaget wanted to measure area notions during the CIFT, he used ideas connected with cows eating grass in a field. As a result, two difficulties arose. One was the communication of the notion that Piaget intended the child to abstract. Secondly, Piaget had to infer that the child's responses really did reflect one form of area conservation.

To eliminate these kinds of irrelevant conditions, the GST focused upon the ideas of "space covered" or "amount of green space showing". These ideas, it was argued, would more directly measure area notions and also eliminate the inferences necessary if a Piagetian approach were followed.

Another procedure which Piaget sometimes used during the CIFT could also increase a subject's attention to an irrelevant attribute. When Piaget arranged both sets of buildings in similar positions on the fields and then spread one set of buildings, this transformation tended to attract attention to the spread arrangement. To overcome this, the identical arrangement of objects was omitted in all scored items in each of the GST forms.

The Three Forms of the Green Space Test. To manipulate the number of irrelevant attributes, three forms of the GST were designed. The three forms were: the Green Space

Test - Regular (GST-R); the Green Space Test - Shadows (GST-S) and the Green Space Test - Exaggerated Height (GST-EH). The provisions made to achieve such irrelevant attribute changes are discussed next.

Throughout the GST-R which is described in full in Appendix 2, only one layer of black wooden one-inch cubes was placed on each of the two green acetate sheets.

During the administration of the GST-EH one of the two acetate sheets had towers of one-inch black wooden cubes placed on it. The GST-EH procedures are specified in full in Appendix 3. Specifically, in item 3, a stack of three cubes was placed on the left acetate sheet; in item 4, a tower of four cubes was placed on the right acetate sheet. In all subsequent GST-EH items, towers were placed on the acetate sheets where the blocks were spread. The purpose of this procedure was to increase the number of irrelevant attributes. Thus greater amounts of extraneous areas and volumes, extra faces, line segments and so on were introduced; the net effect being an increased stimulus load and consequently a higher hypothesis load for the child.

It is apparent that although the GST-R and the GST-EH procedures manage to control some of the factors in question better than the CIFT, other steps need to be taken in order to effect further reductions in the number of irrelevant stimuli presented to the subject. A reduction of irrelevant features and the production of two-dimensional space can be achieved through the use of shadows. By eliminating the height of the cubes used during the GST-R and the GST-EH, as well as the thickness of the acetate, a reduction in the number of irrelevant stimuli was anticipated. This was hypothesized because if the third dimension of the test materials was removed, all extraneous heights, faces, volumes and areas as well as some congruencies, vertices and line segments would be abolished. Then one could more truly assert that two-dimensional surface concepts were being measured.

Shadows were produced in the GST-S[5] by placing appropriate green regions and poster board squares on the staging of an overhead projector. By jointly altering the distance of the projector from a vertical screen and the size of the objects and regions placed on the overhead staging, regions equal in area to the green acetate sheets used in the GST-R and the GST-EH as well as shadows equal in area to a face of the wooden one-inch cubes were produced on the vertical screen. In the present study this was achieved by placing a vertical screen fifty-two inches from an overhead projector. Then poster board squares, one-quarter inch to a side generated shadows, one-inch square in size. Two rectangular pieces

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5 The complete testing procedures for the GST-S are presented in Appendix 1.

of green acetate each one and twenty-nine thirty-seconds of an inch by two and seven-sixteenths of an inch produced two, eight by ten inch, green regions. By placing the poster board squares on these acetate sheets, green regions with the necessary shadows were produced on the vertical screen.

The possibility then arose that the use of shadows might introduce another unintended source of difficulty. That is, children's beliefs about what causes shadows might influence the children's conservation responses. In his early writings, Piaget[6] concluded that when asked what causes shadows, children's answers could be categorized according to the following levels:

Level I - Shadows emanate from some outside source such as the night or trees.

Level II - Shadows spring from the object itself.

Level III - Shadows are substances which run from the light.

Level IV - Shadow is an absence of light caused when an object blocks out the light from the projection plane.

The age at which Level IV was attained was the same as that reported for the attainment of Stage IIIA of the

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6 Jean Piaget, The Child's Conception of Physical Causality, London, Kegan, Paul, Trench, Trubner, 1930, p. 181.

CIFT. That is, both Level IV beliefs about the nature of shadows and the qualitative conservation of the CIFT attained in Stage IIIA occurred during the concrete operational stage. Thus until children become conservers, their beliefs about the nature of shadows could affect their responses in studies which involved shadows.

Piaget[7] dismissed any such negative influences during a study in which children were asked to predict the shape of shadows produced by a variety of objects interposed between a light source and a vertical screen. He argued that since the resultant shadows were subsequently cast and the child was allowed to check the accuracy of his shape prediction, any conjectures that the child made about the nature of shadows could also be corroborated at this time — at least the opportunity was present.

Although no check of what causes shadows was possible in the present study, no prediction concerning the shadows or their production was requested either. Also direct reference to shadows was not made in the experimental protocols; only green regions were mentioned. Moreover, all

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7 Jean Piaget and Barbel Inhelder, The Child's Conception of Space, London, Routledge and Kegan Paul, 1967, p. 195.

subjects in an extensive pilot study[8] as well as the subjects in the present study seemed to be acquainted with images cast by an overhead projector and were not surprised by the shadows on the screen. In fact, several children requested an opportunity to play with the machine in order to project shadows of their own making.

Both the GST-S and the GST-R were interpreted as falling along Dwyer's realism of representation continuum[9] discussed in the previous chapter. The GST-S was judged as more abstract than the GST-R and so the GST-R contained more irrelevant attributes. A deliberate attempt to increase the number of irrelevant attributes was made during the GST-EH presentation. Therefore, the consequent irrelevant stimulus load ran from a high during the GST-EH to a low during the GST-S.

It will be recalled from the review of the problems connected with area conservation and discussed in the previous chapter that the postulate eventually formulated was that during a uniformly administered area conservation test, children in the transitional stage will give the

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8 Stan Pasko, The Effect of Varying the Number of Irrelevant Cues on Performance During a Piagetian Conservation of Area Task, unpublished manuscript of a pilot study, 1976. 14 p.

9 Francis M. Dwyer, Jr., "Adapting Visual Illustrations for Effective Learning", in the Harvard Educational Review, Vol. 37, No. 2, 1967, p. 252.

greatest number of conservation responses when the number of irrelevant attributes is least.

Specific tests of this postulate can now be articulated in the following hypotheses:

H_1 - Children in the transitional stage will give a greater number of conservation responses during the GST-S than during the GST-R.

H_2 - Children in the transitional stage will give a greater number of conservation responses during the GST-S than during the GST-EH.

H_3 - Children in the transitional stage will give a greater number of conservation responses during the GST-R than during the GST-EH.

To summarize, the rationale underlying the development of the GST was presented. The procedures used in varying the number of irrelevant attributes which gave rise to the three forms of the GST were also discussed. These procedures and the resultant GST forms included: 1) shadows in the GST-S; 2) three dimensional items in the GST-R; 3) stacks of cubes in the GST-EH. Finally, the hypotheses emanating from the manipulations of these irrelevant attributes were listed.

A Description of the Basic Green Space Test Format. Each of the three forms of the GST just described reflect a specific attempt to control the number of irrelevant features.

However, the procedures followed within each form were identical. That is, for each of the three GST forms, the same questions were asked, the same number of objects were placed on each of the acetate sheets, and the positioning of these objects was identical within each comparable item. This basic GST format is described next.

In each form, the congruence of the two green regions to be used in that form was established first. In the GST-R and the GST-EH, two eight by ten inch green acetate sheets were positioned so that they were parallel to and slightly above the edge of the construction paper used as background. In the GST-S, the two and seven-sixteenth edges of the two green acetate sheets were positioned slightly removed from the top staging edge of the overhead projector. When projected, this latter arrangement produced two eight by ten inch green regions on the bottom portion of the vertical screen.

For each test, if the child claimed that the green regions covered different spaces, he was asked to identify the larger green area which was then replaced by a spare. After the replacement, if the child claimed that the green regions were still unequal, he was asked to imagine that each green region covered the same space. Any subjects asked to imagine equality were eliminated. That is, if the child were asked to imagine the equality of the green regions, the next three items of that particular form were administered and that child was eliminated from the study. The two green regions were then moved to one side and the congruence of the objects to be placed on these green regions was determined by visual inspection. Here the tester spread the necessary number of objects for the appropriate forms. Twenty-five black, wooden, one-inch cubes for the GST-R and fifty-five for the GST-EH were placed on the background paper in front of the child. For the GST-S, twenty-five poster board squares were spread on the staging of the overhead projector. Again in each form of the GST, the subject was asked whether each object covered the same space. Any of the objects that the child felt were different in size were replaced. If the child still claimed that some objects were unequal, a request that he imagine that they were all the same was included in the test format. If this last request were made, two subsequent items for that form were attempted and that subject was not tested further and eliminated from the sample.

The necessary green regions were again arranged as previously described and the appropriate objects were placed on them by the tester. See Appendix 4 for the positioning of the objects.

Following each placement of objects on the green regions, the child was asked to decide whether the amount of green that remained was the same or different. To reduce response set and to determine the presence of equal and unequal notions the following features were incorporated into items three to eleven. These were: 1) in items six and nine, different numbers of objects were positioned on the appropriate green regions; 2) the spread objects appeared three times on the right acetate and four times on the left; 3) for every GST item the appropriate object arrangement was constructed and then the objects were removed; 4) the order of the words "same" and "different" in the questions where the child was asked to decide the amount of green space that remained was alternated from item to item; 5) in the GST-EH items, the different sized towers were used an almost equal number of times. That is, fifteen towers of two, sixteen towers of three and sixteen towers of four were used.

During a pilot test an attempt was made to standardize question presentation by using pre-recorded cassette tapes. Cueing problems were encountered because taped portions had to be provided for each option within an item and because several variations of a general sequence within any one item were possible. Consequently, the following difficulties developed: 1) finding the appropriate block of questions; 2) starting the tape at the beginning of the appropriate questions; 3) skipping through unnecessary items. Therefore, for the present study, the tester asked the sequence of questions established by the protocol specified in Appendices 1, 2 and 3.

In the foregoing paragraphs, the GST format was described. The scoring procedures for the GST are discussed next.

The basic scoring procedures incorporated into the GST forms closely resemble those outlined for the Concept Assessment Kit-Conservation developed by Goldschmid and Bentler[10]. These included: 1) use of Same and More type of record; 2) no numerical scoring for the correct identification of the equivalence of the green regions or of the objects to be placed on the green regions; 3) choices had to be accompanied by explanations.

In items five to eleven, the subject was asked to give explanations for his answer. Such explanations were included in the GST forms for the following reasons. Piaget requested such explanations when he administered the CIFT. Inhelder _et al_.[11] argued that in testing for conservation merely selecting from a choice of options

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10 Marcel L. Goldschmid and Peter M. Bentler, _Concept Assessment Kit-Conservation, Manual and Keys_, San Diego, 1968, p. 25-26.

11 Barbel Inhelder, Magali Bovet, Hermine Sinclair and C.D. Smock, "On Cognitive Development", in the _American Psychologist_, Vol. 21-1, No. 2, 1966, p. 162.

could not properly establish the presence of conservation ability; explanations were essential. Finally the combination of choice and explanation would help eliminate what Shantz and Sigel[12] have labelled false positives; that is, giving credit for responses that were initially given for the wrong reason and then merely repeated.

It is important to note that in the present research, the child was scored a conserver or a nonconserver in each item. To be scored a conserver, the child had to give a conservation response and to provide an adequate explanation within each item.

Numerical scoring was not done in items three and four since these items could be completed by children in Piaget's Stage I[13] or Flavell and Wohlwill's Phase 1[14]. These Stages and Phases were discussed in the previous chapter.

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12 Carolyn Uhlinger Shantz and Irving E. Sigel, Logical Operation in Children, A Training Study, Washington, Educational Resources Information Center, United States National Institute of Education, 1967, p. 35, ED 020010.

13 Piaget, Inhelder and Szeminska, Op. Cit., p. 263-264.

14 John H. Flavell and Joachim F. Wohlwill, "Formal and Functional Aspects of Cognitive Development", David Elkind and John H. Flavell, (eds.), Essays in Honor of Jean Piaget, London, Oxford Press, 1969, p. 100-101.

For each GST form a perfect score of seven was possible. This total was made up of single points given for each correct choice followed by an adequate conservation explanation for items five to eleven. Subsequently the scores attained within each form will be referred to as Conservation Scores. Complete scoring instructions are included in Appendix 4.

In spite of the changes made in the GST, a basic similarity to Piaget's CIFT was deemed to exist. In essence, the GST format most closely resembled the CIFT that Piaget used with his subjects Gar and Doc[15]. The GST also resembled Goldschmid and Bentler's Concept Assessment Kit which in turn resembled the procedures that Piaget used with Gar and Doc. These similarities provided the bases for maintaining that the GST possessed content validity. That is, performance during the GST could be interpreted as a sample performance[16] or defined as representative of performance from the appropriate Piagetian universe of area conservation.

By following the same basic GST format just outlined but with variations in the number of irrelevant stimuli, it

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15 Piaget, Inhelder and Szeminska, Op. Cit., p. 264-265.

16 David J. Fox, The Research Process in Education, New York, Holt, Rinehart and Winston, 1969, p. 370.

was held that the effect of irrelevant attributes on area conservation responses could be determined.

2. The Subjects.

The research subjects were Grade two students. This grade was chosen because: 1) as Flavell and Wohlwill concluded in their analysis of the Uzgiris data described earlier, transitional children are dominant in Grade two; 2) as noted earlier Flavell and Wohlwill's Phase 2 closely matches Piaget's CIFT Stage II and the ages suggested in both instances are on the average those of Grade two children.

The children attended classes in a northeastern Ontario school district which is predominantly rural.

The seven schools selected had a total enrolment of 208 Grade two children. All of the randomly selected group of 148 children were administered all three forms of the GST. Subsequently, seventy-two transitional children were identified. The mean age of the transitional children was 94.88 months with a standard deviation of 6.10 months. The ages of the transitional subjects are listed in Appendix 7.

A transitional child was operationally defined for this study as a subject who did not obtain a zero total or a total of twenty-one when his scores on each of the three GST forms were summed. This operational definition is consistent with Flavell and Wohlwill's description of Phase 2 children noted earlier. In Phase 1, (P_a) = 0 to reflect the absence of the given operation. In the present study this would be reflected in zero totals. This total was chosen because it was felt chance scores had been reduced to a minimum with the allotment of a point only for a correct choice followed by a correct explanation. Sixteen zero totals were found and these subjects were eliminated. Also, during the latter portions of Phase 3 and in Phase 4, [P(+)] approaches the ideal value of one because the influence of task variables is minimal and (P_a) is stable. This last condition would be reflected in the present investigation by perfect scores of seven for each form. Twenty-four subjects achieved totals of twenty-one and these scores were not analyzed further.

Also deleted from further statistical analysis were the scores of twenty-six children who rejected the equivalence of the green regions, the blocks or the shadows. Ten children were lost to the sample for a variety of reasons such as cassette recorder failure and incomplete test procedures.

3. The Experimental Method.

Four female teachers not employed in the target district acted as testers. The testers participated in several training sessions which included explanations of the test format, role playing sessions in which members of the tester group gave the test to one another and finally several trial administrations with children from two adjacent school districts. During the trial procedures, the individual testers were supervised by the author.

The actual testing was done within each school in a room provided for the testing period.

Within the room, a desk and a chair were arranged so that the child could look down upon the desk. The tester also sat at the desk to carry out the necessary manipulations. On another table fifty-two inches from a portable screen an overhead projector was positioned. The staging of the overhead projector was blocked off from the child's view with a piece of white bristol board. This paper was attached to the projector on the side facing the screen. The child was thus prevented from seeing the manipulations which the tester carried out on the projector staging. However, from a chair placed three feet from the screen and off to the right hand side of it, the subject could view all object and green region placements on the screen which he was requested to watch at the appropriate times.

The tester escorted each child from his classroom to the testing room. On the way, the tester asked the child if he would like to play a game. The tester also expressed the hope that the subject would find the game interesting.

After entering the testing room, the child was directed to sit on the appropriate chair. The tester then asked the child if he had ever used a tape recorder. Each child was allowed to record and hear himself answering questions about his name, the date and the name of his school. The child was subsequently informed that the tape recorder would be turned on later but that he should ignore it.

A Warm-up and Familiarization exercise (WUF) was begun with each subject. The purpose of the WUF was to acquaint the child with the words "size", "cover more space" and "cover the same space" and the concept of surface. Complete instructions for administering the WUF are presented in Appendix 5.

It was decided to include the WUF in the present study because of the Taloumis[17] findings. She found such a warm-up helpful when she later tested certain surface concepts some of which corresponded to the ones investigated in the current research. The inclusion of the WUF also provided for the possible elimination of any subject who experienced a great deal of difficulty with the WUF vocabulary and concepts.

For each of the first four questions of the WUF, the child was seated so that he could look down upon the top of the desk. On the desk top was the piece of brown construction paper which acted as background. In each display of three white paper squares which the tester arranged on the brown paper, the child was asked to identify the following: In question one, the subject was required to find the two squares which were the same size; question two involved finding the square which was bigger than the others; questions three and four entailed identifying the squares which covered the same amount of space and the square which covered more space respectively.

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17 Thalia Taloumis, The Relationship of Area Measurement as Affected by Sequence of Presentation of Piagetian Area Tasks in Grades One Through Three, unpublished doctoral thesis presented to New York University, New York, 1973, p. 46.

Finally, for the last two questions of the WUF, the child was asked to move to the chair which was positioned three feet from the vertical screen. He was then requested to watch the screen and to observe what happened. In question five, the child was asked to pick out the squares which covered the same amount of space from the shadow display of three squares. From three other square shadows cast on the screen for question six, the subject was asked to select the one that covered more space than the others.

This progression from size to space covered was followed because Taloumis[18] reported such an order easier for children.

No numerical scoring of the WUF was done. Only the selection that each subject made was crossed out by the tester as the WUF was being administered. These selections were recorded on a scoresheet similar to the one included in Appendix 6.

Of the six WUF items completed by any one subject, the greatest number of incorrect items for any one subject was one. The greatest number of incorrect selections made by all subjects was eight and this occurred in item five where the question requested finding squares which covered the same amount of space. None of the 148 children randomly

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18 Ibid.

selected were rejected as unsuitable subjects on the basis of their WUF performances.

Following the WUF, a cassette tape recorder was turned on and the resulting tape-recorded GST session was later marked by a rater to obtain each subject's Conservation Score.

To assess conservation responses, the three GST forms were administered to each child. Six possible administration sequences are possible. All six sequences were used. Sequence alternation was incorporated to offset the cumulative learning effects which could occur during the GST. The permuted form sequences were randomly assigned to the subjects.

At the end of the testing session, each child was asked if he would help keep a secret. The secret was not to tell any of his classmates or siblings about the test. This precaution was taken to guard against the possible contamination of any subsequent testing which was to be carried out with other subjects. The reason for the precaution was explained to each subject.

The total testing time for each subject was approximately twenty-five minutes.

The testing was carried out for approximately one month during April and May.

4. The Statistical Techniques for Analyzing the Results.

The dependent variable was the area Conservation Score obtained by each subject for each GST form. The independent variable, the number of irrelevant attributes, was varied by the use of the three GST forms.

The only Conservation Scores analyzed were those attained by children determined to be in the transitional stage.

The research hypothesis was tested in the null form by means of the Friedman test for repeated measures with a correction for tied scores[19] with alpha at the .05 level. For the post hoc analysis, .95 confidence levels were calculated for the various pairings of the GST forms.

The Friedman test statistic with an adjustment for tied scores was chosen for the following reasons: 1) the Conservation Score data did not meet either normality, homogeneity of variance or correlated condition assumptions[20] necessary to apply the appropriate analysis of variance; 2) the Friedman test statistic is analogous to the one-way

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19 Maurice Kendall, Rank Correlation Methods, London, Griffin, 1970, p. 100.

20 V. Keith, Design and Analysis, Ottawa, University of Ottawa Press, 1972, p. 167.

analysis of variance F test for repeated measures[21]; 3) as the number of subjects and the number of conditions increase from two, Friedman[22] asserts that the efficiency of his statistic when compared to the conventional one-way analysis of variance with repeated measures ranges between 0.637 and 0.919; since the number of subjects and the number of conditions in the present study were seventy-two and three respectively, it seems reasonable to conclude that the efficiency of the Friedman statistic in the current case tends toward 0.919; 4) the forty-four subjects who attained pairs of tied Conservation Scores were considered too numerous to allow the application of the uncorrected version of the Friedman test statistic[23].

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21 Milton Friedman, "The Use of Ranks to Avoid the Assumption of Normality Implicit in the Analysis of Variance", in the _Journal of the American Statistical Association_, Vol. 32, No. 200, 1939, p. 675-701.

22 _Ibid._, p. 683.

23 Kendall, _Op. Cit._, p. 100.

CHAPTER III

PRESENTATION OF THE RESULTS

In this chapter, the results obtained from the statistical analyses, described in the previous chapter, are presented and discussed. The sections in their order of presentation are: 1) The Green Space Test Scores; 2) Testing the Hypotheses.

1. The Green Space Test Scores.

The Conservation Scores which the transitional subjects attained during the GST-S, the GST-R and the GST-EH are reported in Appendix 7. All possible scores between zero and seven occurred in each of the three GST forms and these frequencies are presented in Table II. The frequencies shown in Table II, when plotted, reveal a negatively skewed distribution for the GST-S and the GST-R and a bimodal distribution for the GST-EH. In Table III, the means, medians and modes of the Conservation Scores are reported. Of these three measures, the medians and modes reflect the central tendencies of the data most appropriately.

Error frequencies for items three and four are enumerated in Table IV. It will be recalled that in item three, one poster board square in the GST-S, one cube in the GST-R, and one tower of three cubes in the GST-EH was

Table II.-

Frequencies of the Conservation Scores Attained During the Shadows(S), Regular(R), and Exaggerated Height (EH) Forms of the Green Space Test by Transitional Grade Two Subjects.

Scores	Green Space Test		
	S	R	EH
Zero	9	5	32
One	4	5	9
Two	2	6	3
Three	6	4	1
Four	4	5	3
Five	16	10	5
Six	14	9	8
Seven	17	28	11

Table III.-

Means, Medians and Modes of the Conservation Scores Attained During the Shadow(S), Regular(R) and Exaggerated Height Forms of the Green Space Test by Transitional Grade Two Subjects.

	Green Space Test S	R	EH
Mean	4.51	4.85	2.50
Median	5.00	6.00	1.00
Mode	7.00	7.00	0.00

Table IV.-

Frequencies of Incorrect Choices Made in Items 3 and 4 of the Shadow(S), Regular(R) and Exaggerated Height(EH) Forms of the Green Space Test by Transitional Grade Two Subjects.

Item	Green Space Test S	R	EH
3	5	6	6
4	3	2	32

positioned on one of the two green regions. The other green region was left blank. The subject was subsequently asked to decide if the remaining green space was the same or if one of the two green regions had more green space remaining. If the child decided that one of the green regions had more green space remaining, he was asked to select the appropriate acetate sheet. The error rate in item three in all three GST forms was low and this was interpreted within the framework of Piaget's[1] discussion of an analogous item in the CIFT. Piaget maintained that children who successfully completed such an item gave evidence that the essential character of the Euclidean axiom was present. In the present research the high success rate in item three was considered proof of the claim that the majority of the children understood the task at hand. This contention is further strengthened if it is recalled that at the outset of each testing situation each transitional subject successfully completed a WUF exercise made up of related vocabulary and space concepts. In addition, any child who was asked to imagine the congruence of any pairs of green regions or the items to be positioned on these green regions or who was unable to answer any GST item correctly and so achieved a zero total when his

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1 Jean Piaget, Barbel Inhelder, and Alina Szeminska, <u>The Child's Conception of Geometry</u>, London, Routledge and Kegan Paul, 1960, p. 263.

Conservation Scores were summed did not form part of the sample used in the present research.

The large number of errors evident in Table IV for item four of the GST-EH may have occurred because of the display constructed in this item. It will be remembered that in item four of the GST-EH, a single block was positioned on the left hand green acetate sheet while a tower of four blocks was placed on the right hand acetate sheet. The subjects were then asked to determine if one green acetate sheet had more green space remaining or if the amount of green space remaining was the same. Thirty-two of the seventy-two transitional children claimed that more green space remained on the acetate sheet with the greater number of blocks on it. It appeared as if the tower placed on one of the acetate sheets became the dominant feature on which the subjects in the current study keyed. The above procedure was further interpreted as an indication of some interference in the child's reasoning process.

Since no explanations were requested in items three and four in any of the three GST forms, a further analysis of item four in the GST-EH was precluded.

In Table V, the frequencies of the incorrect explanations given by the subjects for items five to eleven for all three GST forms are tabulated. The two main

Table V.-

Frequencies of Incorrect Explanations Given in Items 5 to 11 of the Shadow(S), Regular(R) and Exaggerated Height(EH) Forms of the Green Space Test by Transitional Grade Two Subjects.

	Green Space Test								
		S			R			EH	
Item	A[a]	C[b]	Mi[c]	A	C	Mi	A	C	Mi
5	15	0	3	17	0	0	8	28	3
6	9	21	5	6	20	1	5	39	6
7	14	0	5	11	1	5	9	27	8
8	14	2	5	14	0	7	11	30	6
9	14	23	2	15	14	2	7	38	4
10	19	2	1	17	0	5	11	30	6
11	20	9	2	16	2	3	12	32	4

a Incorrect explanations in which abutting or spread block arrangements were mentioned.

b Explanations based on counting and an incorrect conclusion.

c All remaining incorrect explanations generally categorized as miscellaneous.

categories into which these explanations could be placed were: 1) the incorrect explanations, to designate the subject's choice of a green region which contained more green space because there were more blocks on it; 2) the incorrect explanations, to indicate that a green region contained more remaining green space because the blocks on it were spread or abutting. All other reasons were varied and consisted of such explanations as, "I looked at them" or "These are lying down and these are standing up". An examination of Table V reveals that errors based on counting procedures generally occurred more often in items six and nine in all three GST forms. Also apparent in these items is the almost two-fold increase in counting based errors from the GST-S and the GST-R to the GST-EH. A large increase in errors where blocks were counted is also evident when the GST-EH and the GST-S or the GST-R forms are compared with the GST-EH consistently showing the highest number of errors. The error rates for the abutting arguments and the miscellaneous category appeared relatively stable and no trends in these two error rates were discernible.

2. Testing the Hypotheses.

To apply the Friedman test statistic, the Conservation Scores attained by each transitional subject across the various GST forms were ranked. The ranks assigned to the Conservation Scores for each of the seventy-two transitional subjects appear in Appendix 8. A rank of one was assigned to the highest Conservation Score attained by the subject; a rank of two was assigned to the second highest Conservation Score while the lowest Conservation Score attained by that subject was coded with a rank of three. When two Conservation Scores achieved by a single subject were tied, a mid-rank was assigned to both Conservation Scores. That is, the two ranks which would have been allotted had no tie occurred, were totalled, and this rank sum was then divided by two to obtain a mid-rank.

The frequencies of the various rank orders which were given to the GST Conservation Scores in the present study are enumerated in Table VI. In thirty-eight of the seventy-two GST-EH rankings, this form received the rank of three which in turn means that the Conservation Scores were lowest.

The value for chi square reported in Table VI, as calculated with the Friedman test statistic adjusted for tied ranks, was 34.09 which is significant at the .05 level.

Table VI.-

Frequencies of Rank Orders and Mean Ranks Assigned to the Conservation Scores Attained During the Shadows(S), Regular(R), and Exaggerated Height(EH) Forms of the Green Space Test by Transitional Grade Two Subjects.

	Rank Orders of Conservation Scores Attained During the Green Space Test			
	S	R	EH	Frequency
	1	2	3	7
	1	3	2	1
	1	2.5	2.5	8
	1.5	1.5	3	18
	1.5	3	1.5	2
	2	1	3	13
	2.5	2.5	1	2
	2.5	1	2.5	5
	3	1	2	5
	3	2	1	2
	3	1.5	1.5	9
Mean Rank Sums	1.91	1.60	2.49	

The value of chi square with two degrees of freedom was 34.09 which is significant at the .05 level.

Alpha at the .05 level $\chi^2_2 = 5.99$.

The value of chi square which is reported in Table VI indicates that significant differences do exist. Determining which pairs of the GST rank sums are significantly different from zero provides the information necessary for testing the hypothesized relationships.

H_1 - Children in the transitional stage will give a significantly greater number of conservation responses during the GST-S than during the GST-R.

H_2 - Children in the transitional stage will give a significantly greater number of conservation responses during the GST-S than during the GST-EH.

H_3 - Children in the transitional stage will give a significantly greater number of conservation responses during the GST-R than during the GST-EH.

To test these relationships, confidence intervals for the three possible pairings of the GST forms were calculated. These confidence levels are shown in Table VII. Significant differences were found for the GST-S and the GST-EH pairing and the GST-R and the GST-EH pairing. The GST-S and the GST-R pairing was not significantly different.

Further interpretations and discussions of the results presented in this chapter are undertaken in the next chapter.

Table VII.-

.95 Confidence Intervals for Green Space Test Rank Pairs Based on the Friedman Test Statistic.

Mean Rank Sums Compared	Confidence Intervals
S-R	- .102 to .714 N.S.
S-EH	- .984 to -.169 S.
R-EH	-1.290 to -.474 S.

CHAPTER IV

DISCUSSION OF THE RESULTS

The interpretations of the significant and non-significant results obtained in the current research are presented in the following two sections.

1. The Significant Results.

The significant differences indicated between the Conservation Scores of the GST-S and of the GST-EH, and of the GST-R and of the GST-EH offer support for Flavell and Wohlwill[1]. It will be recalled that Flavell and Wohlwill advanced the claim that as the (P_b) factor was increased, the (P_b) portion of (k) was also increased. Coincidentally, if (P_a) remained constant, the (P_a) portion of (k) also remained constant. In such situations, Flavell and Wohlwill hypothesized that performance [P(+)] would be decreased. Specifically in terms of the present research, as the number of irrelevant attributes, (P_b), was increased, the logic, the (P_a) factor, which the children had previously exhibited in the GST-S and the GST-R tended to disappear. Consequently the Conservation Scores in the GST-EH were decreased.

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1 John H. Flavell and Joachim F. Wohlwill, "Formal and Functional Aspects of Cognitive Development", David Elkind and John H. Flavell, (eds.), Studies in Cognitive Development, Essays in Honor of Jean Piaget, London, Oxford Press, 1969, p. 67-120.

The importance of the above interpretation becomes even more meaningful when it is remembered that the same children were tested using all three forms of the GST. On that basis, it can be asserted that the logical thinking which these children displayed in the GST-S or the GST-R was also available to them in the GST-EH. Its reduced appearance in the GST-EH can with some certainty be ascribed to the increased irrelevant attribute load. This conclusion is advanced because the three GST forms were alike in structure, in format and in content; the only dimension which was varied was the irrelevant attribute load. As described in a previous chapter, this increased irrelevant attribute load in the GST-EH was achieved by positioning a number of blocks in the form of towers on one of the green acetate sheets. The introduction of such towers in the GST-EH prompted many of the transitional subjects to make errors which were based on a counting of the number of blocks on each acetate sheet. Such errors will be subsequently referred to as C errors.

These C errors occurred in the GST-EH items where the remaining green spaces were in fact equal. Here many transitional children judged the remaining green spaces to be unequal. When asked to explain how they had figured out their answer, these children made remarks like, "This one has more blocks on it, so it has more green space showing". This response which is representative of many similar responses is accepted as evidence of the fact that the children who were asked to solve the problem where an equal amount of green space remained were incapable of overriding the powerful perceptual information provided by the massed towers. That is, they were overcome by a perceptual dimension of the problem which was irrelevant to its solution.

Likewise, in items six and nine of the GST-EH where the green spaces which remained were actually unequal, many transitional children correctly concluded that the remaining green regions were unequal. However, when asked to explain their conclusion, they proceeded to make a C error by responding that because this acetate sheet had more blocks on it, it had to have more green space remaining. In essence, the procedure adopted by many transitional subjects when completing a GST-EH item can be characterized as follows. When asked to decide whether the remaining green spaces were equal or unequal, many children stated that one green acetate sheet had more green space remaining. Upon being asked to explain how they had figured out their answers many children replied, "Because this one has more blocks on it", or "This one has two blocks and this one has five".

Similar faulty reasoning has been analyzed by Lunzer[2]. He concluded that children between eight and ten years of age reasoned as follows. A factor either remains constant or it does not. That is, compensating for the various transformations of a characteristic does not change that characteristic. Lunzer then asserts that the child then appears to conclude that if one dimension of an object remains constant over transformations, all other dimensions must also remain constant. Lunzer labels such a correct conclusion based on one dimension of an object, conservation. When that same reasoning leads to an incorrect conclusion about the other dimensions of that object, Lunzer labels this false conservation. Furthermore, Lunzer maintains that only in the formal operational stage is the child able to consider the hypotheses of conservation and nonconservation simultaneously.

When the C errors in the GST-EH, discussed previously, are considered, it seems reasonable to conclude that a combination of conservation of an inequality and false conservation of an inequality occurred in the present research. This conclusion is derived from an analysis of the faulty reasoning procedures used by the transitional subjects.

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2 E. A. Lunzer, "Formal Reasoning", E. A. Lunzer and J. F. Morris, (eds.), Development in Human Learning, New York, American Elsevier, Vol. 2, 1968, p. 277-285.

From the statements and selections made by these children, the following inferences were made. When faced with a GST-EH display, the subjects seemed to be overwhelmed by the block inequality and to centre on this relationship of inequality. This inequality also appeared to become the basis for the decisions which these children made when judging the green spaces which remained. Consequently, when determining on which green acetate sheet more green space remained, the children seemed to reason that it must be the acetate sheet with the greatest number of blocks on it.

As a result, the child's initial decision that an inequality did indeed exist suggested that a conservation of an inequality relationship had been established. Such a conservation then seemed to be the premise for the child's determination of the remaining green space and his choice of the green acetate sheet with the greater number of blocks on it. This latter procedure prompted the use of the label false conservation of an inequality, because the child's final conclusion was reached through the application of a consistent but incorrect reasoning process.

Moreover, it is also claimed that the above sequence of faulty reasoning can be used to account for the occurrence of the C error in items six and nine in the GST-S or the GST-R. For example, in item six of the GST-R, a cluster of four blocks and a spread display of three blocks appeared on the green regions. This initial display in item six presented the subject with an inequality relationship. Reasoning based on that inequality relationship apparently served as the child's guide for subsequent judgments in that item. Up to this point the logic displayed by the child was consistent and correct. That is, the child was correct in his choice of the inequality relationship as well as in his assumption that a greater number of blocks meant a smaller amount of remaining green space. However, many subjects who had initially accepted this inequality relationship then proceeded to identify the green region with the four blocks on it as having more green space remaining. This apparent contradiction was explained away with comments such as, "This one has more blocks on it so it has more green left". Obviously, the children had keyed on the cues provided by the number of blocks. Having decided that the number of blocks was the attribute involved in the solution of the problem, the subjects then appeared to proceed as if they were unaware of the attribute "amount of green space remaining". That is, once they had centred on the number of blocks, the children ceased to consider the total array and proceeded to use their verified hypothesis as the guiding principle for future problem solving in that item.

The above illustration is typical of the procedures used by many children to complete items six and nine of the GST-S or the GST-R. In the above example, it has been shown that a line of reasoning which is faulty but constant can be deduced, and that this line of reasoning resembles the one used by children who made C errors in the GST-EH.

The application of such incorrect but consistent reasoning processes in one item, however, raises the possibility that such procedures could contaminate succeeding items. That is, the incorrect solution used by a subject in item six of the GST-S could carry over to item seven of the GST-S. This possibility occurs in the Piagetian protocol for administering the CIFT. It will be recalled that in the Piagetian procedure for administering the CIFT, buildings are added to a display which the experimenter has just finished discussing with a subject. Consequently, when the Piagetian procedure is used, there seems to be no provision made for controlling the possible carryover of a solution used previously by the subject. There are also no arrangements included in the Piagetian approach to determine when this carryover occurs.

It may well be that conservation and false conservation occur in any situation where equal and unequal block displays are positioned on a region and questions about the remaining areas are asked. What may confound the entire testing process in traditional Piagetian procedures in the CIFT is the inability to separate out component abilities. For example, such a possibility exists when two objects appear on each of the two green regions and the experimenter asks the subject about the amount of green space remaining. From the display, the child could quickly determine that the number of blocks was the same. With this equality established, the child could reply same and be answering a question about the number of blocks in spite of the fact that the experimenter's question was about the remaining green spaces. When asked to state how he had figured out his answer, the child could reply, "Because they both have the same number of blocks on them". In reality, the child could still be talking about the number of blocks, but be classified incorrectly as conserving area; the assumption on the experimenter's part being that the child was referring to the areas occupied by those blocks. Thus an original conservation about the number of blocks could well obscure a false conservation about the amount of area which remained because of the problems surrounding the identification of these component reasoning processes.

It is important to remember that in the present research, such contaminations were minimized by the use of the following procedures: 1) when any GST item was completed by the subject, the blocks or posterboard squares used in the display were removed and a new display was constructed for the succeeding item; 2) when a child decided that more green space remained he was asked to point to the region which contained more green space; 3) items six and nine, in which unequal green spaces remained, were interspersed among items in which the remaining green areas were equal. This last feature incorporated into each GST form raised another concern about Piaget's protocols during the CIFT.

Of the approximately twenty-six situations which Piaget described in his discussion of the CIFT, only three involved displays where the green spaces which remained were different. Two of these displays involved placing two buildings on one green region and one building on the other. The remaining situation consisted of a display in which three buildings were placed on one green region and two on the other. This lack of inequality situations brings into question Piaget's contention that the Euclidean axiom was applied operationally by age eight. That is, because Piaget tended to use mostly test situations in the CIFT in which equal remaining green spaces were involved, the application of the Euclidean axiom in situations where the remaining green spaces were unequal was not systematically considered. Therefore, Piaget's claims about the stage sequences for the CIFT would necessarily be incomplete, if not incorrect.

As previously discussed, the inclusion in the present research of those items where the remaining green spaces were unequal, as well as of those items where the remaining spaces were equal, provided for a more complete investigation of the reasoning processes used in the acquisition of one particular form of area conservation. More importantly, the format of the present study allowed an analysis of the behaviour exhibited by children in situations where both equal and unequal relationships were involved. This latter provision subsequently allowed the identification of the consistent but incorrect reasoning procedure described earlier.

If the foregoing interpretations of the constant but faulty reasoning displayed by the transitional children in the present research are accepted, then other conclusions also become possible. For example, the two-fold increases in the C errors observable when items six and nine of the GST-EH and the GST-R, or when items six and nine of the GST-EH and the GST-S are compared, can well be considered two variations of the same phenomenon.

Consider the display in item six of the GST-EH which consisted of one layer of four blocks on one acetate sheet and three towers of two, three and four blocks respectively on the other acetate sheet. Clearly such a display provided two possibilities for errors. During one incorrect reasoning procedure, children appeared to be overwhelmed by the block inequality. Evidence for this is found in their conclusions that the remaining green spaces were unequal and in the explanations which they forwarded for their conclusions such as "This one with more blocks on it has more green space showing". Such a procedure is obviously similar to the one used by many subjects to reason out items six and nine of the GST-S or the GST-R described above. In the second incorrect reasoning procedure, the child seemed able to ignore the misleading cue suggested by the towers. However, when faced with the four blocks on one acetate and three towers on the other, he chose the acetate with the four blocks on it. From these responses, it was inferred that a uniform but inaccurate line of reasoning had formed the basis for the decisions made by the child in that particular item. That is, the child appeared to concentrate on the number of block arrays while apparently ignoring the total number of blocks in those arrays.

Therefore, it seems reasonable to conclude that the incorrect reasoning procedures just described account for the two-fold increase in C errors when item six of the GST-EH and the GST-S forms or the GST-EH and the GST-R forms are contrasted. Obviously, an analysis similar to the one just proposed for the occurrence of C errors in item six could be readily repeated for the occurrence of C errors in item nine of all three GST forms. It is also claimed that the conclusions finally derived should be identical to those reached above for item six.

To recapitulate, the significant differences between the GST-EH and the GST-S as well as between the GST-EH and the GST-R were discussed in terms of the following dimensions: 1) the increase in the number of irrelevant attributes; 2) the possibility that conservation of an inequality and false conservation of an inequality were occurring simultaneously in items six and nine of all three GST forms but especially in the GST-EH forms; 3) the features incorporated into the GST format to overcome some of the difficulties inherent in the Piagetian CIFT approach. Some of the above considerations can also be used to provide interpretations of the nonsignificant difference determined between the GST-S and the GST-R. These interpretations are developed in the succeeding section.

2. The Nonsignificant Results.

In this section, the relative load of irrelevant attributes when the GST-S and the GST-R are compared is discussed briefly. Recommendations for further research to substantiate the speculations included in this chapter are included in the last part of this section.

When comparisons between the GST-S and the GST-R are made, the relative irrelevant attribute load can be interpreted as being the same. This conclusion can be inferred in the present research from the nonsignificant difference indicated between these two GST forms as well as from the following analysis. In both the GST-S and the GST-R, except for items six and nine, the number of objects on each green region was the same. During the presentation of the GST-S and the GST-R, the perception of the displays could well have been alike. Furthermore, it is cautiously advanced that the perceptual displays placed before the subject in both the GST-S and GST-R forms were similar in all essential respects. From these displays, a child could establish a notion of equality quite readily within that particular item and then continue to apply an equality relationship to complete items five, seven, eight, ten and eleven successfully and correctly. Consistent but incorrect solutions were derived for items six and nine because, as previously argued, the child appeared to perceive an inequality relationship and to employ that inequality relationship to solve the succeeding portions of that item. Such patterns become evident in a re-examination of the GST-S and GST-R Conservation Scores, their distributions and the error frequencies reported in the previous chapter.

It must be hastily added, however, that the rationale for conservation of an inequality and false conservation of an inequality discussed in the two sections of this chapter requires further research.

Other questions which should be investigated include the following: To what degree does the Piagetian CIFT approach in which subsequent items are constructed from previous displays contaminate succeeding responses? What developmental stages would result from the administration of the GST-R made up of items which result in unequal remaining areas? In the study undertaken to answer this latter question, it is recommended that the explanation and selection routine used in the present study be incorporated. This recommendation is forwarded for the following reasons. If the researcher relies only on the statements and explanations given by the transitional children he runs a high risk of contaminating the research with what Shantz and Sigel[3] have labelled false positives. This notion of false positives was discussed in Chapter II and results in giving credit for responses which on the surface appear correct but which are founded on incorrect assumptions or procedures. Support for this recommendation is also provided by Brainerd who asserts that "explanations [...provide] insights into the nature of the structure or structures under consideration."[4a] If the

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3 Carolyn Uhlinger Shantz and Irving E. Sigel, Logical Operation in Children, A Training Study, Washington, Educational Resources Information Centre, United States National Institute of Education, 1967, p. 35, ED 020010.

4a Charles J. Brainerd, "Judgments and Explanations as Criteria for the Presence of Cognitive Structures," in the Psychological Bulletin, Vol. 79, No. 3, 1973, p. 178.

selection routine is included in any subsequent study of remaining areas, another advantage which would accrue would be the ability to recognize the extended ideas of conservation and false conservation[4b] suggested in the previous section. It will be recalled that in the present study where the conservations and false conservations are alleged to have occurred, an initial relationship became the basis for subsequent judgments which were consistent but which were grounded on the wrong assumptions.

A high priority must also be given to research concerned with the relationships between the GST and other conservation abilities, in particular, the conservation of number. The role of conservation of number seems to be a factor almost totally ignored in area conservation research. As the current analysis has demonstrated, the irrelevant attributes provided by the number of block arrays appear to be a characteristic of some importance in the ultimate solution of the problem.

Some other important topics to be researched include: 1) the relationship between the traditional Piagetian procedure and the GST-R; 2) a reassessment of the place of area conservation in the currently accepted developmental sequence of conservation acquisition; and 3) the relationship

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4b Lunzer, Op. Cit., p. 277-285.

of the GST-R to the Goldschmid and Bentler area conservation sub-test contained in Form C of the Concept Assessment Kit-Conservation[5].

To summarize, in this final section, the non-significant results were discussed. Research recommendations were also proposed to help determine the following: 1) the occurrence of conservation of an inequality and false conservation of an inequality during the GST; 2) the relationship of the GST-R to the Piagetian CIFT, other conservations, and Goldschmid and Bentler's area conservation subtest.

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5 Marcel L. Goldschmid and Peter M. Bentler, Concept Assessment Kit-Conservation, Manual and Keys, San Diego, 1968, p. 25-26.

SUMMARY AND CONCLUSIONS

Piaget asserts that the growth of logic underlies intellectual development. By analyzing children's responses to his Cows in the Field Test, he traces the mental evolution of one component of area conservation. But even though he recognizes that material circumstances can influence any mental process, Piaget's theory does not account for this factor in any systematic way.

Flavell and Wohlwill try to show the weighted influence (k) of task variables (P_b) on the growth of operations (P_a) by postulating the formula [$P(+) = P_a \times P_b^{(1-k)}$]. These authors recommend tracing the evolution of a single structure from the time it first appears until it is generally available. They predict that task variables have their greatest influence on Piagetian conservation responses during the period they label transitional.

One task variable which has been empirically shown to influence responses is the number of irrelevant attributes present in that task. This finding prompted the prediction that transitional children would achieve a higher Conservation Score when the number of irrelevant attributes was least.

Three Green Space Test forms, the Shadow form, the Regular form, and the Exaggerated Height form were subsequently developed to test this prediction. All three Green

Space Test forms were identical in content and in structure. The number of irrelevant attributes was the only factor varied from form to form.

Each of the 148 randomly selected children from seven Grade two classes completed a Warm-Up and Familiarization exercise. One of six permuted presentation orders of the Regular, the Shadows and the Exaggerated Height forms of the Green Space Test was administered to each subject to determine his Conservation Scores. Subsequently the Conservation Scores attained by seventy-two Grade two subjects who were considered to be in the transitional stage of area conservation acquisition were analyzed.

The research hypothesis was tested in the null form at a significance level of .05. The Friedman statistic with a correction for tied ranks was used to test for significant differences.

Significant differences were indicated between the Shadows form of the Green Space Test and the Exaggerated Height form of the Green Space Test as well as between the Regular form of the Green Space Test and the Exaggerated Height form of the Green Space Test.

The resultant significant differences were interpreted as support for Flavell and Wohlwill's prediction that increased irrelevant attributes decrease performance. These significant differences were also analyzed in terms of the errors made by the transitional children while they were completing the Green Space Tests. The possibility that conservation of an inequality and false conservation of an inequality might account for the erroneous reasoning procedures which produced these errors was also discussed. Also investigated was the nonsignificant difference between the Regular form of the Green Space Test and its possible relation to conservation and false conservation.

Recommendations to verify the presence of conservation of an inequality and false conservation of an inequality were forwarded. Other investigations to determine the relationship between area conservation and other related conservations were also suggested.

BIBLIOGRAPHY

Evans, Richard I., Jean Piaget, The Man and His Ideas, New York, Dutton, 1973, xi-189 p.

The author held a series of interviews with Jean Piaget about his developmental theory, its relationship to other fields of psychology, to philosophy, and to education. These interviews were videotaped and later transcribed to form this book. A good compilation of Piaget's major ideas written in a form that is highly readable.

Flavell, John H., The Developmental Psychology of Jean Piaget, Toronto, Van Nostrand, 1963, xvi-472 p.

This author is one of the first and still one of the foremost American interpreters of Piagetian theory. His book provides an excellent review of Piaget's work, as well as a thorough discussion of his theory.

Flavell, John H. and Joachim F. Wohlwill, "Formal and Functional Aspects of Cognitive Development", David Elkind and John H. Flavell, (eds.), Studies in Cognitive Development, Essays in Honor of Jean Piaget, London, Oxford University Press, 1969, p. 67-120.

These authors present a critical evaluation of Piaget's theory, accepting parts of it as well as recommending refinements and extensions. The major extension involves accounting for decalages during conservation performance by providing for the influence of task variables. An important attempt at remedying a condition Piaget himself has identified as a source of performance variations.

Gelman, Rochel, "Conservation Acquisition, A Problem of Learning to Attend to Relevant Attributes", in the Journal of Experimental Child Psychology, Vol. 7, No. 2, 1969, p. 167-187.

An elaborate and successful procedure to improve conservation responses during length and number tasks is described in this research. Data to support a performance improvement in somewhat more remotely related conservations such as mass and liquid are also reported. The successful training programme involved getting children to pay attention to relevant transformations. A very useful analysis of the influence of irrelevant stimuli during typical conservation tasks is detailed.

Goldschmid, M. L., and P. M. Bentler, Concept Assessment Kit-Conservation, San Diego, Educational and Industrial Testing Service, 1968, 26 p.

The authors combined the following Piagetian conservation tasks — two dimensional space, substance, number, continuous and discontinuous quantity, weight — to produce two parallel test forms. Area and length appear in a separate form. High internal consistency, reliability and between forms reliability for this test battery have been reported by the authors. Also provided is a set of age norms for total scores within each form. This tends to obliterate the uneven development that often characterizes conservation developments. The test format is easily understood and administered. These instruments would provide a good first source for classroom teachers.

Piaget, Jean, The Child and Reality, New York, Grossman, 1973, 182 p.

In this book, Piaget presents the essential elements of his theory as it pertains to the intellectual growth of children. Piaget also investigates the relationship of his theory to Freudian, Gestaltist and other psychological orientations. An excellent book, written in an easily understood style.

Piaget, Jean, and Barbel Inhelder, The Psychology of the Child, New York, Basic Books, 1969, xiv-173 p.

Here, Piaget traces mental growth up to adolescence. Arguments are presented to substantiate the primacy of the inherited adaptive process to attain equilibrium both at the physical and mental levels. Strongly recommended for a good overview of cognitive development.

Piaget, Jean, Barbel Inhelder, and Alina Szeminska, The Child's Conception of Geometry, London, Routledge and Kegan Paul, 1969, vii-411 p.

This book details the research and theoretical inferences that Piaget makes about the evolving notions that children have about position, length, angles, areas and solids. A valuable source book for the above conservations as well as one point of departure for the present research.

Taloumis, Thalia, The Relationship of Area Conservation to Area Measurement as Affected by Sequence of Presentation of Piagetian Area Tasks in Grades One Through Three, unpublished doctoral thesis presented to New York State University, New York, 1973, 220 p.

This research reported a number of findings which supported the contemporaneous and interdependent development of area conservation and area measurement abilities. This thesis provided many suggestions incorporated into the test forms developed for this research.

APPENDIX 1

PURPOSE, MATERIALS AND DIRECTIONS FOR THE ADMINISTRATION OF THE GREEN SPACE TEST - SHADOWS FORM

Green Space Test
Form S (Shadows)

Purpose

To test for the presence of the Euclidean axiom when applied to area using shadows (when the number of irrelevant cues is postulated to be less than for Forms R or EH).

Materials

An overhead projector set up 52 inches from a vertical screen so that the bottom edge of the illuminated portion of the screen is 3 feet from the floor and parallel to it. Off to the right-hand side and 3 feet from the vertical screen a chair should be positioned so that the subject (S) can observe the screen. A piece of white bristol board 9 by 12 inches, attached to the side of the overhead facing the vertical screen to block the staging from the S's view. Thirty poster board squares, ¼ inch to a side, and three rectangular green acetate sheets each 1-29/32 by 2-7/16 inches.

Procedures

1 i) The S should sit on the chair facing the vertical screen. The experimenter (E) places the green acetate sheets on the overhead staging so that the 1-29/32 inch edges are close to one another.

The 2-7/16 edges are lined up close to the upper edge of the staging. The green regions should appear parallel to the line separating the illuminated portion from the bottom unilluminated portion of the screen.

ii) Then ask the S, "Does this cover the same space (pointing to one green region on the staging) as this (pointing to the other) or does one cover more?"

Procedures 1 iii) to 1 vi) are used only if needed.

iii) If the S claims one green region covers more space than the other say, "Point to the one which covers more space". Remove the green region indicated by the S and replace.

iv) Then ask, "Does this cover the same space (pointing to one green region on the staging) as this (pointing to the other) or does one cover more?"

v) If the S still claims one green region covers more space than the other, then a) Say, "Let's imagine that each green part covers the same space, then we can play the game"; b) Complete only items 2, 3 and 4 of Form S and <u>do</u> <u>not</u> test further.

vi) The acetate sheets should be moved to one side of the staging.

2 i) Twenty-five one-quarter inch poster board squares should be spread on the staging of the overhead so that none overlap or touch one another.

ii) Then ask the S, "Do each of these cover the same space (sweep hand across the squares on the staging) or do any cover more space?"

Procedures 2 iii) and 2 iv) are used only if needed.

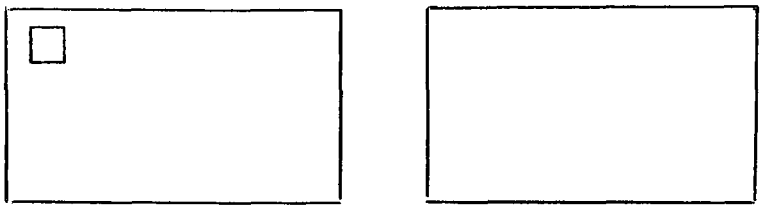
iii) If the S claims one or more squares cover more space, say, "Point to any that cover more space". Remove and replace these. Then ask "Do each of these cover the same space (sweep hand across the squares on the staging) or do any cover more space?"

iv) If the S still claims one or more squares cover more space, then a) Say, "We'll have to imagine that each of these covers the same amount of space, then we can play the game"; b) Complete only items 3 and 4 of Form S and <u>do not</u> test further.

v) All poster board squares should be moved to one corner of the staging.

3 i) Say to the S, "Watch what I do".

ii) Then the green acetate sheets are lined up as in Procedure 1. The E then places one poster board square on the green acetate sheet as illustrated below.



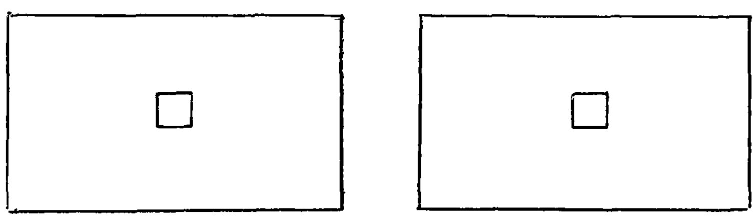
iii) Then ask, "Does one have more green space showing or do they both have the same amount of green space showing?"

iv) If the S claims one region has more green space showing then say, "Point to the one which has more green space showing".

v) Then the poster board square on the acetate sheet should be removed.

4 i) Say to the S, "Watch what I do".

ii) Then poster board squares should be simultaneously arranged on each acetate sheet as illustrated below.



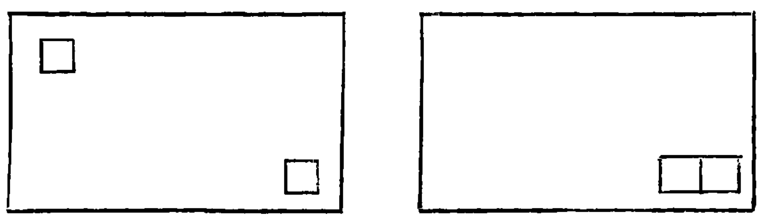
iii) Then ask, "Does each one have the same amount of green space showing or does one have more green space showing?"

iv) If the S replies that one region has more green space showing then say, "Point to the one which has more green space showing".

v) Then all the poster board squares on the acetate sheets should be removed.

5 i) Say to the S, "Watch what I do".

ii) Then two poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below.



iii) Then ask, "Does one have more green space showing or do they both have the same amount of green space showing?"

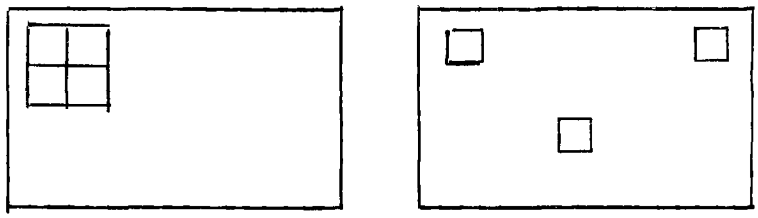
iv) If the S claims one region has more green space showing then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

6 i) Say to the S, "Watch what I do".

ii) Then three poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below. Then the fourth poster board square should be added to the left hand acetate sheet as shown.



iii) Then ask, "Does each one have the same amount of green space showing or does one have more green space showing?"

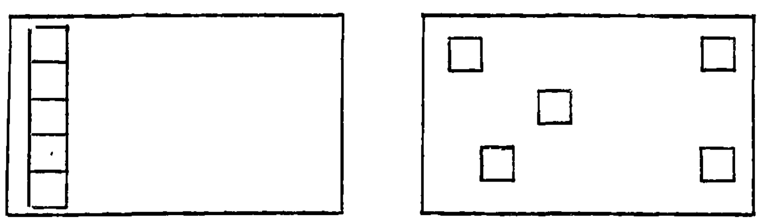
iv) If the S claims one region has more green space showing then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

7 i) Say to the S, "Watch what I do".

ii) Then five poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below.



iii) Then ask, "Does one have more green space showing or do they both have the same amount of green space showing?"

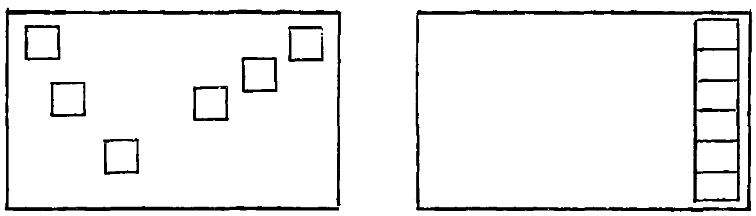
iv) If the S claims one region has more green space showing then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

8 i) Say to the S, "Watch what I do".

ii) Then six poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below.



iii) Then ask, "Does each one have the same amount of green space showing or does one have more green space showing?"

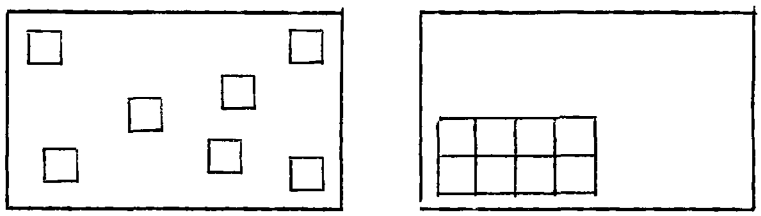
iv) If the S claims one region has more green space showing, then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

9 i) Say to the S, "Watch what I do".

ii) Then seven poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below. Then the eighth poster board square should be added to the right hand acetate sheet as shown.



iii) Then ask, "Does one have more green space showing or do they both have the same amount of green space showing?"

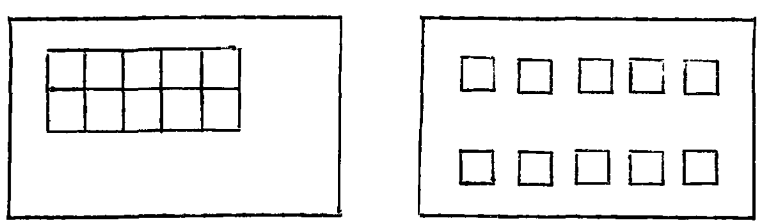
iv) If the S claims one region has more green space showing then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

10 i) Say to the S, "Watch what I do".

ii) Then ten poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below.



iii) Then ask, "Does each one have the same amount of green space showing or does one have more green space showing?"

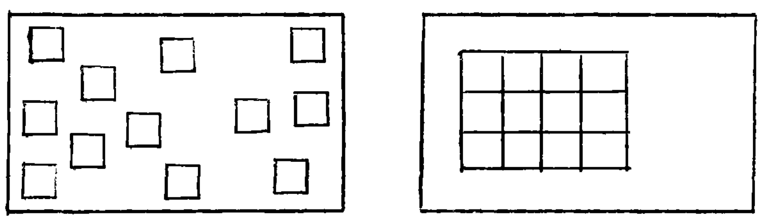
iv) If the S claims one region has more green space showing then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

11 i) Say to the S, "Watch what I do".

ii) Then twelve poster board squares should be arranged on each acetate sheet, one at a time on each sheet and simultaneously, as illustrated below.



iii) Then ask, "Does one have more green space showing or do they both have the same amount of green space showing?"

iv) If the S claims one region has more green space showing, then say, "Point to the one which has more green space showing".

v) Ask the S, "How did you figure out your answer?"

vi) Then all the poster board squares on the acetate sheets should be removed.

APPENDIX 2

PURPOSE, MATERIALS AND DIRECTIONS FOR THE ADMINISTRATION OF PROCEDURES 1 AND 2 OF THE GREEN SPACE TEST - REGULAR FORM

APPENDIX 2

Green Space Test
Form R (Regular)

Purpose

To test for the presence of the Euclidean axiom when applied to area using one layer of blocks (when the number of irrelevant cues is postulated to be greater than for Form S and less than for Form EH).

Materials

A low desk at which the subject (S) can be seated so that he can look down on the desk top. An 18 by 24 inch piece of brown construction paper to act as background for manipulations carried out by the experimenter (E). Three 8 by 10 inch green acetate sheets. Thirty black wooden one-inch cubes.

Procedures

1 i) The S should be seated at the desk and the background construction paper should be in place on the desk top. The E then places the green acetate sheets on the brown construction paper so that the 8 inch edges are close to one another. The 10 inch edges are lined up so that they are close to the 24 inch edge of the brown paper and parallel to it.

ii) Then ask the S, "Does this cover the same space (pointing to one green region) as this (pointing to the other) or does one cover more?"

Procedures 1 iii) to 1 vi) are used only if needed.

iii) If the S claims one green region covers more space than the other say, "Point to the one which covers more space". Remove the green region indicated by the S and replace.

iv) Then ask, "Does this cover the same space (pointing to one green region) as this (pointing to the other) or does one cover more?"

v) If the S still claims one green region covers more space than the other, then, a) Say, "Let's imagine that each green part covers the same space, then we can play the game; b) Complete only items 2, 3 and 4 of Form R and do not test further.

vi) The acetate sheets should be moved to one side of the desk.

2 i) Twenty-five black wooden one-inch cubes should be spread on the brown background paper so that none overlap or touch one another.

ii) Then ask the S, "Do each of these cover the same space (sweep hand across the blocks) or do any cover more space?"

Procedures 2 iii) and 2 iv) are used only if needed.

iii) If the S claims one or more blocks cover more space, say, "Point to any that cover more space". Remove and replace these. Then ask, "Do each of these cover the same space (sweep hand across the blocks) or do any cover more space?"

iv) If the S still claims one or more blocks cover more space, then a) Say, "We'll have to imagine that each of these covers the same amount of space, then we can play the game"; b) Complete only items 3 and 4 of Form R and do not test further.

v) All the blocks should be moved to one side of the desk.

3 Turn to Appendix 1, pages 135 to 141, for Directions 3 to 11 and read poster board squares as one layer of blocks.

APPENDIX 3

PURPOSE, MATERIALS AND DIRECTIONS FOR THE ADMINISTRATION OF PROCEDURES 1 AND 2 OF THE GREEN SPACE TEST - EXAGGERATED HEIGHT FORM

APPENDIX 3

Green Space Test
Form EH (Exaggerated Height)

Purpose

To test for the presence of the Euclidean axiom when applied to area using layers of blocks for all arrangements where the blocks are spread (when the number of irrelevant cues is postulated to be greater than for Form S or R).

Materials

A low desk at which the subject (S) can be seated so that he can look down at the desk top. An 18 by 24 inch piece of brown construction paper to act as background for manipulations carried out by the experimenter (E). Three 8 by 10 inch green acetate sheets. Sixty black wooden one-inch cubes.

Procedures

1 i) The S should be seated at the desk and the background construction paper should be in place on the desk top. The E then places the green acetate sheets on the brown construction paper so that the 8 inch edges are close to one another. The 10 inch edges are lined up close to the 24 inch edge of the brown paper and parallel to it.

ii) Then ask the S, "Does this cover the same space (pointing to one green region) as this (pointing to the other) or does one cover more?"

Procedures 1 iii) to 1 vi) are used only if needed.

iii) If the S claims one green region covers more space than the other, say, "Point to the one which covers more space". Remove the green region indicated by the S and replace.

iv) Then ask, "Does this cover the same space (pointing to one green region) as this (pointing to the other) or does one cover more?"

v) If the S still claims one green region covers more space than the other then a) Say, "Let's imagine that each green part covers the same space, then we can play the game"; b) Complete only items 2, 3 and 4 of Form EH and <u>do not</u> test further.

vi) The acetate sheets should be moved to one side of the desk.

2 i) Fifty-five black wooden one-inch cubes should be spread on the brown background paper so that none overlap or touch one another.

ii) Then ask the S, "Do each of these cover the same space (sweep hand across the blocks) or do any cover more space?"

Procedures 2 iii) and 2 iv) are used only if needed.

iii) If the S claims one or more blocks cover more space, say, "Point to any that cover more space". Remove and replace these. Then ask, "Do each of these cover the same space (sweep hand across the blocks) or do any cover more space?"

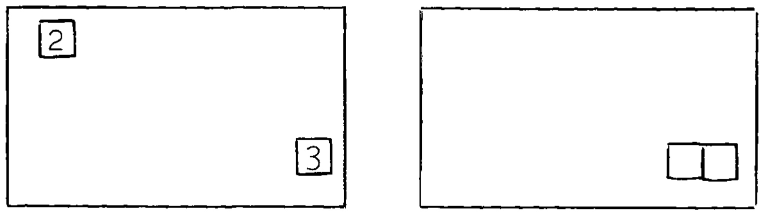
iv) If the S still claims one or more blocks cover more space, then a) Say, "We'll have to imagine that each of these covers the same amount of space, then we can play the game"; b) Complete only items 3 and 4 of Form EH and do not test further.

v) All the blocks should be moved to one side of the desk.

3 Turn to Appendix 1, pages 135 to 141, for Directions 3 to 11 and read poster board squares as blocks. The blocks on one of the acetate sheets should appear as towers. In Procedure 3, a tower of three blocks should be used.

4 In Procedure 4, a tower of four blocks should be placed on the right hand acetate sheet. In Procedures 5 to 11, the blocks which are spread should be stacked in layers as indicated in each of the following diagrams. Each stack should be placed on the acetate sheet as a complete tower rather than built up one block at a time.

5



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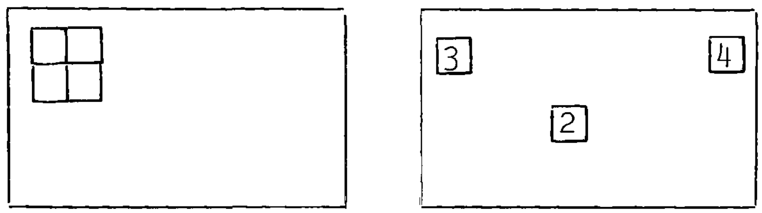

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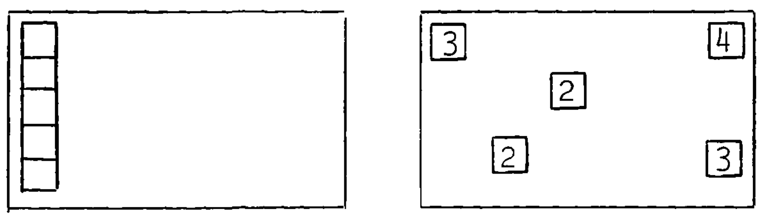

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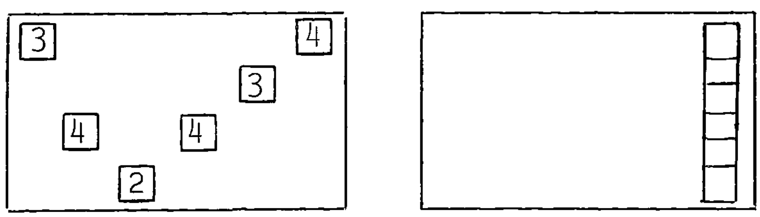

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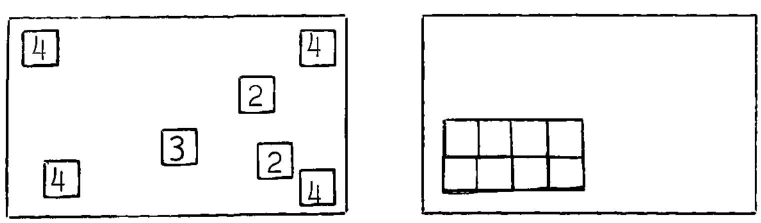

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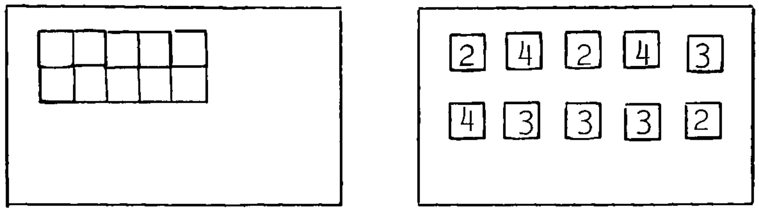
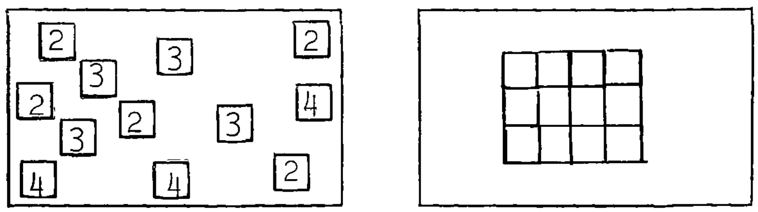


11



APPENDIX 4

SCORING KEY AND SCORESHEET FOR THE THREE FORMS OF THE GREEN SPACE TEST

Scoring Key for the Three Forms of the Green Space Test

Note: Each of the three forms is identically scored.

A. In items 1 to 4 only the child's final Same (S) or More (M) is recorded in the column labelled Same More. There is no further scoring of items 1 to 4.

B. In items 5 to 11, the child's choice of Same (S) or More (M) is recorded in the column labelled Same More.

C. In items 5, 7, 8, 10, 11, one point is allotted and recorded in the Point column if a S response is given followed by an explanation which contains one or more of these ideas.

a) Invariant Number: "There are as many blocks (shadows) on this part as there are in that one"; "There are the same number of blocks (shadows) on both of them, which leaves the same amount of green showing"; etc.

b) Transformation of Positions: "If you put all these together they make a shape exactly the same as that one"; "You could spread all these apart and make them like that one"; etc.

D. In item 6 and 9, one point is allotted and recorded in the point column if a M response is given, the correct region is selected and an explanation provided which includes one or more of these ideas.

a) Variant Number: "There are more blocks (shadows) here than there"; "There are 4 (8) here and only 3 (7) there"; etc.

b) Transformation of Positions: "If you put all these together, they would make a different shape than that one"; "You could spread these apart and then find that there would be one block (shadow) more"; etc.

E. Item 6 or 9 is scored zero (0) if a M choice is followed by an incorrect region selection, regardless of the explanation given.

F. Items 5 to 11 are scored zero (0), regardless of the S or M choice, if one or more of the following occur.

a) No explanation at all.

b) A 'magical' answer such as, "My teacher told me".

c) A perceptual answer such as "They look the same"; "These blocks (shadows) are all spread out".

d) A description of part of the procedure, e.g. "You put some blocks (shadows) on the green parts"; "You made these straight and those spread out".

e) An incorrect region is selected, regardless of the explanation given.

G. Items 5 to 11 are also scored one (1) if the child's answer in that item is logically consistent, but is based on an incorrect counting of the objects on the green regions as evidenced by the two following situations:

a) The child makes a S choice but in his explanation which contains ideas from Section C of the Scoring Key he includes numbers of objects different from those used in the display of that item.

b) The child makes a M choice but in his explanation which contains ideas from Section D of the Scoring Key he includes numbers of objects different from those used in the display of that item and makes the correct region selection.

H. The maximum score possible in each GST form is seven.

APPENDIX 4

Green Space Test

Form (Circle One) Shadows Regular Exaggerated Height

Name ______________________ Birth Date ______________

Date of Testing ______________ School ________________

Sex ____

Same More	Point

1. 

2.

3. 

4. 

5. 

How did you figure out your answer?

Subtotal A

Same More	Point

6. 

How did you figure out your answer?

7. 

How did you figure out your answer?

8. 

How did you figure out your answer?

9. 

How did you figure out your answer?

10. 

How did you figure out your answer?

11. 

How did you figure out your answer?

Subtotal B

Subtotal A	
Subtotal B	
GRAND TOTAL	

APPENDIX 5

DIRECTIONS FOR THE ADMINISTRATION OF THE WARM-UP AND FAMILIARIZATION EXERCISE

APPENDIX 5

Warm-Up and Familiarization Exercise (WUF)

Purpose

To present the words 'size' and 'cover the same (more) space' and familiarize the child with area-related concepts.

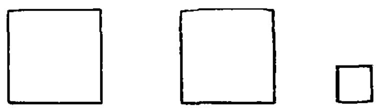
Materials

A sheet by 18 by 24 inch brown construction paper placed on a desk top. The subject (S) should be seated at the desk and he should be able to look down at the desk top. Six sets of three white paper squares with the following edges. Set A: two 4 inch and one 3/4 inch; Set B: one 4 inch, one 1-1/2 inch, one 3/4 inch; Set C: two 3/4 inch, one 1-1/2 inch; Set D: one 4 inch, one 1-1/2 inch, one 1-3/8 inch; Set E: two 1-3/8 inch, one 1-1/2 inch; Set F: one 1-1/2 inch, one 1-3/8 inch, one 3/4 inch. An overhead projector set up 52 inches from a vertical screen so that the bottom edge of the illuminated portion of the screen is 3 feet from the floor and parallel to it. Off to the right hand side and 3 feet from the vertical screen a chair should be positioned so that the S can observe the screen. A piece of white bristol board, 9 by 12 inches, attached to the side of the overhead facing the screen to block the staging from the S's view.

APPENDIX 5

Procedures

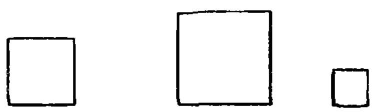
1 a) The S should be seated at the desk and the background construction paper should be in place on the desk top. The experimenter (E) then places the set A squares on the brown paper as illustrated below. (This and all subsequent orders start at the S's left.)



b) Then ask, "Can you find any that are the same size?"

c) Remove the Set A squares.

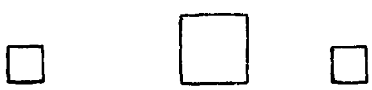
2 a) The E places the Set B squares on the brown paper as illustrated below.



b) Then ask, "Can you find the one that is bigger than the others?"

c) Remove the Set B squares.

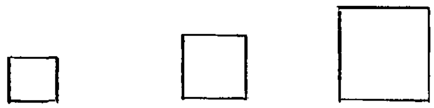
3 a) The E places the Set C squares on the brown paper as illustrated below.



b) Then ask, "Can you find any that cover the same amount of space?"

c) Remove all Set C squares.

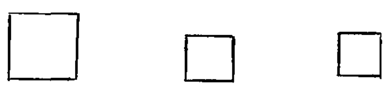
4 a) The E places the Set D squares on the brown paper as illustrated below.



b) Then ask, "Can you find the one that covers more space than the others?"

c) Remove all Set D squares.

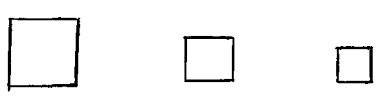
5 a) The E then says, "Please sit on this chair and watch the screen". The E places the Set E squares on the overhead staging so that they are close to the upper edge of the staging. The squares should appear close to the line separating the illuminated portion from the bottom unilluminated portion of the screen. The squares should be arranged as illustrated below.



b) Then ask, "Can you find any that cover the same amount of space?"

c) Remove all set E squares from the staging.

6 a) The S keeps watching the screen while the E arranges the Set F squares on the staging in the manner described in the 5 a) section. The squares should be arranged as illustrated below.



b) Then ask, "Can you find the one that covers more space than the others?"

c) Remove all Set F squares from the staging.

APPENDIX 6

SCORING KEY AND SCORESHEET FOR THE WARM-UP AND FAMILIARIZATION EXERCISE

APPENDIX 6

Scoring Key for the Warm-Up and Familiarization Exercise

A. In each of the sections, the selection(s) made by the child should be crossed out with an X.

B. No further scoring is required.

Warm-Up and Familiarization Exercise

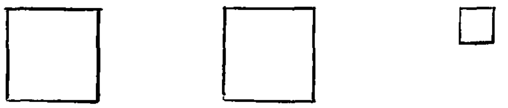
Name ______________________ Birthdate __________

Date of Testing ______________ School ______________

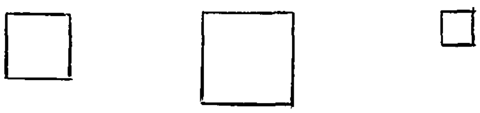
Sex _____

Scoring:

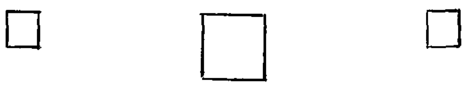
Draw an X on the selection(s) made.

1. 

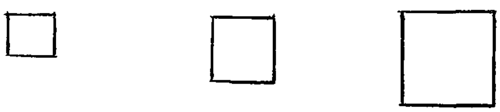
1. Can you find any that are the same size?

2. 

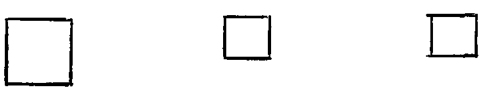
2. Can you find the one that is bigger than the others?

3. 

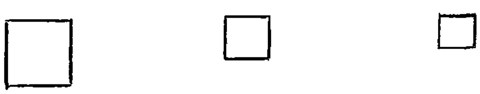
3. Can you find any that cover the same amount of space?

4. 

4. Can you find the one that covers more space than the others?

5. 

5. Please sit on this chair and watch the screen. Can you find any that cover the same amount of space?

6. 

6. Can you find the one that covers more space than the others?

APPENDIX 7

THE AGES OF AND THE CONSERVATION SCORES ATTAINED BY TRANSITIONAL GRADE TWO SUBJECTS DURING THE SHADOWS, REGULAR, AND EXAGGERATED HEIGHT FORMS OF THE GREEN SPACE TEST

APPENDIX 7

The Ages of and the Conservation Scores Attained by Transitional Grade Two Subjects During the Shadows(S), Regular(R), and Exaggerated Height(EH) Forms of the Green Space Test

Subject	Age (in mo.)	Green S	Space R	Test EH	Subject	Age (in mo.)	Green S	Space R	Test EH
1	92	6	7	7	19	90	0	2	1
2	93	4	6	1	20	88	7	6	6
3	97	3	0	0	21	97	6	7	7
4	90	7	7	4	22	94	7	5	0
5	94	1	0	0	23	91	7	7	0
6	89	6	7	5	24	90	7	7	6
7	92	7	6	1	25	90	6	6	4
8	98	3	5	0	26	97	7	4	7
9	107	4	2	0	27	89	3	0	0
10	92	3	7	6	28	95	7	7	5
11	84	0	0	1	29	93	5	1	1
12	105	0	2	0	30	93	1	7	6
13	97	7	7	0	31	96	4	5	0
14	90	4	3	0	32	92	2	4	0
15	85	5	2	2	33	96	5	7	6
16	93	6	4	5	34	97	0	1	0
17	92	5	7	3	35	94	0	3	4
18	89	5	7	7	36	96	7	4	0

APPENDIX 7

The Ages of and the Conservation Scores Attained by Transitional Grade Two Subjects During the Shadows(S), Regular(R), and Exaggerated Height(EH) Forms of the Green Space Test

Subject	Age (in mo.)	Green S	Space R	Test EH	Subject	Age (in mo.)	Green S	Space R	Test EH
37	100	6	7	7	55	94	7	5	5
38	97	6	7	5	56	91	7	7	0
39	92	7	7	0	57	96	0	1	0
40	91	5	5	0	58	106	5	6	0
41	93	6	7	0	59	93	5	6	0
42	91	5	2	1	60	99	5	7	7
43	91	6	5	0	61	97	7	6	7
44	95	0	2	0	62	95	1	5	6
45	102	5	7	7	63	90	3	3	2
46	112	6	7	7	64	97	6	7	7
47	90	5	7	7	65	92	7	7	6
48	109	7	7	0	66	91	6	7	0
49	101	5	5	0	67	89	5	6	0
50	107	5	5	0	68	98	6	6	1
51	99	5	5	0	69	91	0	3	1
52	93	7	7	0	70	105	2	1	1
53	89	3	4	0	71	117	1	1	0
54	89	0	0	2	72	92	6	7	6

APPENDIX 8

THE RANKS ASSIGNED TO THE CONSERVATION SCORES ATTAINED DURING THE SHADOWS, REGULAR AND EXAGGERATED HEIGHT FORMS OF THE GREEN SPACE TEST BY TRANSITIONAL GRADE TWO SUBJECTS

APPENDIX 8

The Ranks Assigned to the Conservation Scores Attained During the Shadow(S), Regular(R) and Exaggerated Height(EH) Forms of the Green Space Test by Transitional Grade Two Subjects

Subject	Green S	Space R	Test EH	Subject	Green S	Space R	Test EH
1	3	1.5	1.5	19	3	1	2
2	2	1	3	20	1	2.5	2.5
3	1	2.5	2.5	21	3	1.5	1.5
4	1.5	1.5	3	22	1	2	3
5	1	2.5	2.5	23	1.5	1.5	3
6	2	1	3	24	1.5	1.5	3
7	1	2	3	25	1.5	1.5	3
8	2	1	3	26	1.5	3	1.5
9	1	2	3	27	1	2.5	2.5
10	3	1	2	28	1.5	1.5	3
11	2.5	2.5	1	29	1	2.5	2.5
12	2.5	1	2.5	30	3	1	2
13	1.5	1.5	3	31	2	1	3
14	1	2	3	32	2	1	3
15	1	2.5	2.5	33	3	1	2
16	1	3	2	34	2.5	1	2.5
17	2	1	3	35	3	2	1
18	3	1.5	1.5	36	1	2	3

APPENDIX 8

The Ranks Assigned to the Conservation Scores Attained During the Shadow(S), Regular(R) and Exaggerated Height(EH) Forms of the Green Space Test by Transitional Grade Two Subjects

Subject	Green S	Space R	Test EH	Subject	Green S	Space R	Test EH
37	3	1.5	1.5	55	1	2.5	2.5
38	2	1	3	56	1.5	1.5	3
39	1.5	1.5	3	57	2.5	1	2.5
40	1.5	1.5	3	58	2	1	3
41	2	1	3	59	2	1	3
42	1	2	3	60	3	1.5	1.5
43	1	2	3	61	1.5	3	1.5
44	2.5	1	2.5	62	3	2	1
45	3	1.5	1.5	63	1.5	1.5	3
46	3	1.5	1.5	64	3	1.5	1.5
47	3	1.5	1.5	65	1.5	1.5	3
48	1.5	1.5	3	66	2	1	3
49	1.5	1.5	3	67	2	1	3
50	1.5	1.5	3	68	1.5	1.5	3
51	1.5	1.5	3	69	3	1	2
52	1.5	1.5	3	70	1	2.5	2.5
53	2	1	3	71	1.5	1.5	3
54	2.5	2.5	1	72	2.5	1	2.5

APPENDIX 9

ABSTRACT OF

The Effect of Varying the
Number of Irrelevant Attributes
on Area Conservation Performance

APPENDIX 9

ABSTRACT OF

<u>The Effect of Varying the Number of Irrelevant Attributes on Area Conservation Performance</u>[1]

To determine how children acquire the various conservations, Piaget has conducted clinical investigations from which he has derived developmental stages. In one series of experiments, he traced how children acquire the Euclidean axiom in area problem situations. However, no systematic attempt to account for the influence of task variables on the acquisition of this form of area conservation is provided either in Piaget's theory or during his investigations.

The present study was undertaken 1) to determine if task variables such as the number of irrelevant attributes influence area conservation acquisition; 2) to test Flavell and Wohlwill's contention that the weighted influence (k) of task variables (P_b) on the application of logic (P_a) is a function of [$P(+) = P_a \times P_b^{(1-k)}$] which has its greatest effect on the performance of children in a stage which they label transitional.

1 Stan J. Pasko, doctoral thesis presented to the School of Graduate Studies of the University of Ottawa, Ontario, September, 1976, 175 p.

APPENDIX 9

Three forms of a Green Space Test, the Shadows form, the Regular form and the Exaggerated Height form, were developed to verify the above postulates through the testing of the following hypotheses:

1. Children in the transitional stage will give a greater number of conservation responses during the Shadows form of the Green Space Test than during the Regular form of the Green Space Test.

2. Children in the transitional stage will give a greater number of conservation responses during the Shadows form of the Green Space Test than during the Exaggerated Height form of the Green Space Test.

3. Children in the transitional stage will give a greater number of conservation responses during the Regular form of the Green Space Test than during the Exaggerated Height form of the Green Space Test.

After finishing a Warm-Up exercise, each of the 148 children completed one of six presentation orders of the Green Space Test forms to determine their Conservation Score.

The Friedman test statistic at a significance level of .05 was applied to test for significant differences between the Conservation Scores attained in each of the Green Space Test forms by the seventy-two subjects who were considered transitional.

Two of the three null hypotheses were rejected. The Green Space Test-Exaggerated Height was significantly different from both the Shadows and Regular forms of the Green Space Test. Such differences were interpreted as support for Flavell and Wohlwill's formula. The Regular form of the Green Space Test was not significantly different from the Shadows form of the Green Space Test.

An analysis of errors made by the transitional subjects in the three forms of the Green Space Test strongly indicated that initial conservations became the bases for subsequent false conservations when the children in the present study were asked to determine the remaining areas in a display.

Suggestions for future research include:

1. Verification of the conservations and false conservations alleged to have occurred in the present investigation;

2. Determining the relationship of area conservation to other conservations;

3. Determining the developmental sequences of area conservation abilities when the test items consist of displays where the remaining area is unequal;

4. Determining the relationship of the Regular form of the Green Space Test to Piaget's original form as well as to the Goldschmid and Bentler area conservation subtest.