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ABSTRACT

The purpose of this study was to investigate the effects of perceptual focus and planar orientation of rods on conservation responses when parallel translations are utilized. The translations along the major axes of symmetry utilized two modes: (1) translation of one of two rods, and (2) simultaneous translation of two of three rods in opposite directions. A review of related literature is given. Seven hypotheses were formulated and analyzed. The study was structured around a factorial design. Subjects were second-grade and third-grade children. Results and conclusions are given, and further research is recommended. (CK)

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THE PIAGETIAN CONSERVATION OF LENGTH AS EFFECTED BY TWO ALTERNATE MODES OF SPATIAL TRANSLATION: A METHODOLOGICAL PROBLEM

TM 002 906

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West Lafayette, Indiana 47907

July 1972

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TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
LIST OF FIGURES	vii
CHAPTER I - INTRODUCTION	1
Statement of the Problem	1
Need for the Study	4
Definitions of Terms Used	6
Objectives	8
CHAPTER II - REVIEW OF RELATED LITERATURE	9
Factors in Conservation Development	10
Steps in Conservation Acquisition	14
Summary	15
The Relationship Between Length Conservation and Linear Measurement	16
Summary	19
Tasks Used for Length Conservation Assessment	20
Summary	24
Theoretical Issues	25
Definitional and Criterial Issues	25
Summary	36
Verbal Versus Nonverbal Conservation Assessment	36
The Use of Relational Terms	42
Summary	44
Situational and Methodological Variables	45
Summary	54
Group Testing of Conservation	55
Summary	61
General Summary	62
CHAPTER III - PROCEDURES	66
Hypotheses to be Tested	66
Statistical Design of the Study	68
The Sample and Testing Schedule	69
Selection and General Characteristics of Sample	69
COL8-2 and COL8-3 Group Test Sample	71

	Page
ICT Sample	73
Across Grade Profile Sample	73
Curriculum	74
Instruments	76
The Group Tests	76
Apparatus	76
Construction and Characteristics	77
Administration of the Group Tests	80
Description of Test Items	82
The Individual Concrete Test	84
Apparatus	84
Construction and Characteristics	84
Administration of the ICT	85
Description of Test Items	86
CHAPTER IV - RESULTS	88
Conditions of Experimentation	88
Combining of Grade Two and Grade Three Data	89
Testing of the Hypotheses	92
Descriptive Statistics	113
CHAPTER V - CONCLUSIONS, IMPLICATIONS, RECOMMENDATIONS AND LIMITATIONS	117
Hypothesis I	117
Conclusions and Implications	118
Hypothesis II	121
Conclusions and Implications	121
Hypothesis III	124
Conclusions and Implications	124
Hypothesis IV	125
Conclusions and Implications	125
Hypothesis V	126
Conclusions and Implications	126
Hypothesis VI	127
Conclusions and Implications	127
Hypothesis VII	128
Conclusions and Implications	128
Conclusions and Implications of Descriptive Data	130
Summary of Major Results	131
Recommendations for Further Research	132
Limitations of the Study	134
LIST OF REFERENCES	138
APPENDICES	
Appendix A	144
Appendix B	160
VITA	163

LIST OF TABLES

Table		Page
1.	Group Test Internal Reliability Estimates.....	79
2.	Range of Item Correlations for Grades Two and Three.....	79
3.	Test-retest Correlations.....	89
4.	Analysis of Variance: 4x2x2 ANOV of Sequence, Apparatus, and Sex of Subject.....	93
5.	Means for Apparatus Levels from Three-way ANOV...	94
6.	Means for Sequence Levels From Three-way ANOV....	94
7.	Cell Characteristics for the Three-way ANOV.....	95
8.	Contingency Table for Observed Frequency Comparison: 100 Percent Criterion.....	97
9.	Contingency Table for Observed Frequency Comparison: 75 Percent Criterion.....	98
10.	Analysis of Variance: Sequence Effects Within COL8-2.....	99
11.	Analysis of Variance: Sequence Effects Within COL8-3.....	100
12.	Neuman-Keuls Sequential Range Test: Significance of Sequence Effects Within COL8-3.....	101
13.	Practice Effects: Conserving Responses for Combined Data Under COL8-2.....	102
14.	Practice Effects: Conserving Responses for Combined Data Under COL8-3.....	102
15.	Analysis of Variance: Practice Effects Within Sequence One.....	103
16.	Analysis of Variance: Practice Effects Within Sequence Two.....	104

Page

17. Analysis of Variance: Practice Effects Within Sequence Three..... 104

18. Neuman-Keuls Sequential Range Test: Practice Effects Within Sequence Two..... 105

19. Analysis of Variance: Male and Female Performance Under COL8-2..... 106

20. Analysis of Variance: Male and Female Performance Under COL8-3..... 107

21. Contingency Table for Observed Frequency Comparison: Sex of Examiner..... 108

22. Contingency Table for Observed Frequency Comparison: Expectancy of Examiner..... 109

23. Correlation Between COL8-2 and ICT Subtests..... 110

24. Correlation Between COL8-3 and ICT Subtests..... 112

25. Proportions of Conserving Responses Under COL8-2..... 113

26. Proportions of Conserving Responses Under COL8-3..... 114

27. Proportions of Subjects Conserving Across Number of Length Conservation Items..... 114

28. Across Grade Profile: Proportions of Conserving Responses Under COL8-2..... 115

29. Across Grade Profile: Proportions of Conserving Responses Under COL8-3..... 116

30. Means for Sequence by Apparatus Interactions.... 123

Appendix
Table

B1. Correlations of Grade Two Scores With Total Test: COL8-2..... 160

B2. Correlations of Grade Two Scores With Total Subtest: COL8-3..... 160

B3. Correlations of Grade Three Scores With Total Test: COL8-2..... 161

Page

B4. Correlations of Grade Three Scores With Total Subtest: COL8-3..... 161

B5. Correlations of Second-Grade Scores With Total Test: COL8-3..... 162

B6. Correlations of Third-Grade Scores With Total Test: COL8-3..... 162

LIST OF FIGURES

Figure		Page
1.	Piaget's Length Conservation Tasks.....	21
2.	An Illusory Transformation.....	24
3.	Beilin's Three-Rod Conservation Task.....	52
4.	Gelman's Three-Rod Conservation Tasks.....	53
5.	Statistical Design Schematic.....	69

Appendix Figure

A1.	Response Booklet Cover Page for COL8-2.....	144
A2.	Response Page and Materials for Items 1 and 2...	145
A3.	Response Page and Materials for Items 3 and 4...	146
A4.	Response Page Materials for Item 5.....	147
A5.	Response Page and Materials for Item 6.....	148
A6.	Response Page and Materials for Item 7.....	149
A7.	Response Page and Materials for Item 8.....	150
A8.	Response Page and Materials for Item 9.....	151
A9.	Response Booklet Cover Page for COL8-3.....	152
A10.	Response Page and Materials for Items 1 and 2...	153
A11.	Response Page and Materials for Items 3 and 4...	154
A12.	Response Page and Materials for Item 5.....	155
A13.	Response Page and Materials for Item 6.....	156
A14.	Response Page and Materials for Item 7.....	157
A15.	Response Page and Materials for Item 8.....	158
A16.	Response Page and Materials for Item 9.....	159

CHAPTER I

INTRODUCTION

Statement of the Problem

Piaget et al. (1960) called a child a conserver of length if the child realized that the length of an object remained constant when moved. In a number of experiments it was demonstrated that between the ages of seven and one-half and eight and one-half years a child could be expected to become a conserver of length.

A classical length conservation task consisted of placing two rods of equal length in a parallel position with ends aligned. When the subject stated that the rods were the same length, one rod was then given a parallel displacement lengthwise. If the child was a conserver he maintained that the rods were still equal. However, if the child was a nonconserver, he maintained that one rod was longer (or shorter) after the displacement even though he agreed to the equality of length of the rods before the displacement took place.

Many length conservation studies, including those of Piaget and his colleagues, utilized a length conservation task which made use of two rods, one of which was moved during the transformation. However, Piaget et al. (1960)

also utilized the two-rod apparatus in conjunction with a transformation in which both rods were moved. When this was done, it was found that some subjects judged both rods to be longer due to the fact that both rods were displaced. For this case it was suggested that nonconservation of length could be attributed "to the absence of an independent reference system to provide a spatial framework for moving objects" [Piaget et al. (1960)].

A second possibility which may help explain nonconserving responses is the perceptual focus of the subject. Because of the fact that a subject may concentrate on the leading extremity or on only one end of a moving rod, it is possible that when only one rod is moved the subject's attention is drawn to just one rod or one side of a rod. This possibility is supported by the work of O'Bryan (1969). In an experimental study of the relationship of eye-movement patterns, O'Bryan found that transitional conservers may be misled by centration on the greater (moved) element of the stimulus configuration, but that the centration is not as general or consistent as that of nonconservers. That is, the nature of the experiment may influence the perceptual focus of the subject. Thus the displacement of two rods simultaneously in opposite directions would appear to lessen the influence on subject focus since then the point of concentration by the subject would be more randomly selected.

Piaget's use of the two-rod apparatus provided a static standard of comparison for the subject when only one rod was moved. However, it was implied that such a standard of comparison was absent when both rods were moved.

The problem of perceptual focus suggests that two rods should be moved, while Piaget's work suggests that a static standard of comparison is a necessity for studying length conservation. Thus, a three-rod apparatus consisting of one static and two movable rods is suggested.

Additionally, in most studies, the rods were placed in a horizontal or vertical position on a flat surface in front of the subject. The effects of planar orientations, other than horizontal or vertical, on subject responses have not been carefully investigated.

The purpose of this study was to investigate the effects of perceptual focus and planar orientation of rods on conservation responses when parallel translations are utilized. The translations along the major axes of symmetry utilized two modes:

(1) translation of one of two rods, and

(2) simultaneous translation of two of three rods in opposite directions.

Four planar orientations were used in which the rods were inclined 0°, 45°, 90°, or 135° to the horizontal. These inclinations were used in sequences of planar orientations.

Need for the Study

Conservation of length is a prerequisite to the understanding of measurement. Piaget et al. (1960) demonstrated that the concept of a common unit of length measure could be traced directly to the basic ability of a child to conserve length. Since such units are used not only for length measurement, but also for locating points in higher dimensional space, and computation of area and volume, their importance is clear. Thus, the concept of length conservation is fundamental to the success of a child in the study of geometrical concepts which involve linear measurement.

Piaget et al. (1960) used individual testing in a clinical setting to study length conservation. In many other experiments involving length conservation, tasks were also administered individually. [Delacy (1967), George (1970), Goldschmid (1967, 1968), Griffiths et al. (1967), Lovell et al. (1962), Nelson (1970), Wheatley (1968), Wheatley and Gotto (1971)]. Though such studies broadly confirmed the findings of Piaget and his co-workers, questions of methodology have been raised which have not yet been satisfactorily answered. Among the methodological issues raised by Piagetian based studies are (1) verbal versus non verbal techniques of assessment and (2) the non-standardization of the definition of conservation.

The use of verbal techniques employed by Piaget, and later utilized by others, may be questioned. In particular,

there is an issue as to whether subjects have an adequate understanding of the relational terms used in task presentation and whether, in general, subjects possess an adequate facility to verbalize the required justification of responses. This is of particular importance if the subject is in Piaget's late pre-operational or early concrete operational stage.

The non-standardization of the definition of conservation is also a serious problem in the study of conservation. Goldschmid (1968) alluded to the serious nature of the problem. Murray (1965, 1971) used illusory figures to study conservation of length. The introduction of illusion replaced the change of position in the classical Piagetian task. In Murray's 1971 study, the introduction of "arrowheads" ignored a condition set forth by Piaget, namely that the site occupied by a rod should not be changed except for placement of the site.

Thus, it appears that methodological variables which may affect the ability to conserve length should be investigated. Two of these variables which have not been adequately studied in length conservation are perceptual focus of the subject and the effects of planar orientation of rods.

In addition to the possible clarification of Piaget's theory through the study of methodological variables, such studies could lead to a more universally acceptable definition of an operational conserver. Some of the criterial

differences presently existent are illustrated by the studies of Braine (1959), Rothenberg (1969) and Smedslund (1963).

Goldschmid (1967), Nelson (1970), and others have investigated sex of subject as a variable in conservation assessment. Bittner and Shinedling (1968) studied sex of experimenter as another possible influencing factor in conservation. Apparently, no one has investigated the role of experimenter expectancy in conservation assessment, but Rosenthal (1966) gave a major discussion of the variable with regard to other research areas. Rosenthal's discussion suggests that the variable of experimenter expectancy should also be investigated in the area of conservation.

The development of group tests, such as those used in this study, provides a means by which the effects of some of the methodological variables can be studied. Along with clarification of Piaget's theory, studies such as this one should lead to more valid and reliable instruments which can be used by the classroom teacher as a diagnostic test for length and measurement readiness.

Definitions of Terms Used

Cardinality. The cardinality of a finite set is the number of elements in the set.

COL8-2. This is the name given to the two-rod apparatus developed for group testing in this study.

COL8-3. This is the name given to the three-rod apparatus developed for group testing in this study.

Conserver of Length. A child is a conserver of length if he realizes that the length of an object is invariant under a spatial transformation.

Gijkm. This is a code designation for groups to whom COL8-2 or COL8-3 were administered. G means group administration; i = A,B where A is the Logansport system and B is the Peru system; j = 2,3 means grade two or three; k = 2,3 means COL8-2 or COL8-3; m = 1,2,3,4 where the numerals refer to the planar orientation sequence.

ICT. This is an individually administered length conservation test developed for this study. The test is composed of Piagetian length conservation tasks utilizing concrete materials which the child can physically manipulate.

Operational Conserver. An operational conserver, as described by Piaget, is a child who conserves on seventy-five percent of the items presented.

Planar Orientation Sequence. The planar orientation sequence is the sequence in which rod orientations were presented to the subjects in this study. These sequences will be designated 1 = 0°, 45°, 135°, 90°; 2 = 45°, 90°, 135°, 0°; 3 = 90°, 45°, 135°, 0°; 4 = 135°, 0°, 90°, 45°.

Spatial Transformation. A spatial transformation, as used in this study, is any movement in one-, two-, or three-dimensional space which can be decomposed into translations, rotations, or combinations of these.

Threshold of Conservation. A child is said to be at the threshold of conservation if he conserves on fifty percent of the items presented.

Objectives

The main objects of the study were

(1) to determine if there were significant differences in conservation responses to items administered utilizing COL8-2 and COL8-3,

(2) to determine if sequencing of planar orientations has a significant effect on conservation responses,

(3) to determine if there are significant practice effects on conservation responses when multiple items of a similar nature are presented to subjects,

(4) to determine if sex of the subject is related to the ability to conserve as measured by COL8-2 and COL8-3,

(5) to examine the effect of sex of the test administrator on length conservation responses for COL8-2, and,

(6) to examine the effect of expectancy of the test administrator on conservation responses as measured by COL8-2.

CHAPTER II

REVIEW OF RELATED LITERATURE

For Piaget, the advent of the period of concrete operations marks a milestone in the intellectual development of the child. It is in this period that a child's cognitive structures reach a stage of completion which provides the basis for logical-mathematical modes of thought. "These structures include classifications, seriations, correspondences (one to one or one to several), matrices or double-entry tables, etc." [Piaget and Inhelder (1969, p. 100)]. The abstract structures, called groupings by Piaget, are "incomplete" in a mathematical-logical sense because they are based on reasoning which is tied to concrete objects. However, these structures provide a transition from schemes of action to general logical structures in which groupings are "completed" to form groups in the mathematical sense. When the child has attained these group structures, he is also able to perform combinatorial analysis. That is, the child then has structures available by means of which he can consider all possible outcomes of factors which may be present in a given problem situation. Piaget and his colleagues have determined that the structures which evolve and reach fruition during the period of concrete operations can be

characterized by studying what they refer to as the "conservations".

Factors in Conservation Development

During the course of Piaget's research in which the intellectual development of the child was studied, four factors were identified which, through their interaction, have primary influence on the progression from one stage to another until the stage of formal operations is achieved. These factors are maturation, experience, social transmission, and equilibration. In conjunction with these factors is Piaget's basic premise that the child is an action-oriented organism.

Maturation is viewed as physiological growth which includes the progressive development of the endocrine and nervous systems. Piaget and Inhelder (1969, p. 154) also noted that one may expect variations in rates at which physical structures develop. The maturation factor plays a definite role in Piaget's stage dependent theory. As Piaget and Inhelder (1969, p. 154) stated,

> Organic maturation is undoubtedly a necessary factor and plays an indispensable role in the unvarying order of succession of the stages of the child's development, but it does not explain all development and represents only one factor among several.

Another factor which helps explain the intellectual development of the child is experience. Piaget and Inhelder (1969, p. 155) noted that in speaking of experience they

consider this factor in terms of actions which the child performs on objects. This experience, gained through exercise, was categorized into physical experience and logico-mathematical experience. The former was described as actions performed on objects in order to abstract object properties. Piaget and Inhelder (1969, p. 155) illustrated this abstraction by an example in which weights of objects were compared independent of object volume and noted that such experience involves assimilation to existent logico-mathematical structures because of the fact that a comparison of weights presupposes the establishment of a relation which is a logical form.

On the other hand, experience may be logico-mathematical. Piaget and Inhelder (1969, p. 155) described such experiences as actions performed on objects which result in the coordination of these actions. Piaget and Inhelder (1969, p. 155) illustrated this type of experience by noting that a child may discover that the number of objects in a set is independent of the order in which they are counted or of the configuration of the objects of the set. In this case learning is the result of the action (counting or object rearrangement) rather than being a result of an inherent object property.

Complementary to the interaction of child and physical objects is the interaction of the child with other human beings. The latter type of interaction is referred to by

Piaget as social interaction or social transmission. This factor is of primary importance because of the effects it produces in the decentering process in which the view of the child evolves from a state of egocentrism to a state in which the child regards himself as one object amongst many in the surrounding environ. Such decentering is necessary for the objective comparisons of object properties which enhance the development of logical structures. In this connection, Piaget and Inhelder (1969, p. 95) stated

> In other words the decentering which is a prerequisite for the formation of the operations applies not only to a physical universe (...) but also necessarily to an interpersonal or social universe. Unlike most actions, the operations always involve a possibility of exchange, of interpersonal as well as personal coordination, and this cooperative aspect constitutes an indispensable condition for the objectivity, internal coherence (that is, their "equilibrium"), and universality of these operatory structures.

Thus, for Piaget, the term "social" should not be used in a narrow sense, but rather it should have the broadest possible connotation.

Though Piaget noted the importance of maturation, experience, and social transmission, he stressed that these factors, while necessary for intellectual development, are, in themselves, not sufficient to account for it. In the formulation of his theory, Piaget has hypothesized a fourth factor which he considers to be of fundamental importance in the child's intellectual development. That factor is the process of equilibration. Equilibration is an internal

process which consists of a sequence of active compensations on the part of the child in response to disturbances or disequilibria. These compensations result in adjustments to existing structures which Piaget and Inhelder (1969, p. 157) described as being both retroactive and anticipatory in nature and which form a permanent system of compensations. That is, compensations made in order to assimilate a piece of new (disturbing) information appear to be applied to other related structures as well as the structure directly related to the new information. This equilibration is accomplished through a feedback system. Thus, new structures which subsume previously existing structures are formed and a state of equilibrium is achieved.

Of prime importance in the process of equilibration through self-regulation is the acquisition of reversibility. Piaget and Inhelder (1969, p. 159) defined reversibility as "a complete - that is, totally balanced - system of compensations in which each transformation is balanced by the possibility of an inverse or a reciprocal". It is reversibility of a transformation which Piaget utilized as the fundamental characteristic of the child in his acquisition of operational conservation.

Even though Piaget considered the four major factors in conservation acquisition necessary, he did not rule out the existence of other pertinent factors. In this sense, Piaget's theory need not be considered as forming a closed

system, but rather as providing a basis for a continuing refinement of a developmental theory.

Steps in Conservation Acquisition

If one studies the protocols which Piaget et al. (1960) reported, he can discern the formulation of a sequence of distinct steps as the child progresses from levels of intuitive thought toward the concrete operational level of thought. As Flavell (1963, p. 245) stated,

> Piaget asserts that the evolution of conservation is a process of equilibration of cognitive actions which contains four major steps, each step comprising in itself an equilibrium state - an isolable "moment" in the continuous equilibration process.

In Step One, the child centrates on only one aspect. For rods initially aligned and then one rod moved, this means the child may focus on the order of end-points of the rods. Piaget et al. (1960) stated that the use of this topological criterion leads the child to couch his replies in terms of expansion or contraction of length. Thus, for this step, the child's response is a nonconserving response. In Step Two, a second property is centrated upon. For rods this may be the opposite end of the rod moved in contrast to the focus of Step One. The result is again a nonconserving response. In Step Three there is a cognitive conjunction of both of the aspects of Steps One and Two, but the focus is still primarily on states. The result may be an inconsistency of responses; some conserving and some nonconserving. At this stage, the child may take note of the

paired ends of the rods, but the perceptual influence of states is still strong enough to override the developing cognitive structure. The child may hypothesize conservation, but the latter is not yet a logical necessity. This is sometimes referred to as intuitive conservation. In Step Four, the conjunction between paired ends is extended to include what Piaget refers to as "composition of sites". Additionally, rather than focusing on states, the child's focus shifts to the transformation which leads from initial to terminal state. At this point, conservation of length becomes a logical necessity and the equilibration process is now complete. This results in a stable state of equilibrium in which there is an inverse for each transformation of rods. Reversibility exists and the child has now attained a level of operational conservation.

Summary

Piaget (1969) has stressed the importance of maturation, experience, and social transmission to the development of intellect in the child. However, Piaget contended that these three factors were insufficient to account for the evolvement of logico-mathematical thought processes. Thus a fourth factor, the process of equilibration, was hypothesized. The primary product of equilibration near the end of the period of preoperations, reversibility, was used as the criterion for the child's passage into the period of concrete operations. In this period logical processes

emerge which provide a basis for the later completion of thought forms to become complete logical structures.

To test the equilibration hypothesis Piaget and his colleagues conducted numerous experiments designed to show how equilibration is evidenced at the onset of concrete operations. The protocols revealed that equilibration is composed of four major steps; centration on one aspect or attribute, centration on a second property, beginnings of cognitive conjunction of aspects, and coordination of properties through a system of compensations which results in reversibility of transformations. The latter guarantees the attainment of operational conservation.

The Relationship Between Length Conservation and Linear Measurement

Piaget et al. (1960, Ch. 4-6) reported a series of experiments in which the evolution of length conservation, linear measurement, and the relationship between the two concepts were studied. Of particular interest are the two experiments which were reported in Chapter Five of this book. The subjects were fifty-nine children aged four to nine years.

In Experiment One, conservation of length was studied in terms of change of position and sub-division. For this purpose, matches and strips of paper were used. After the subject had satisfied himself of the initial equality of length of the rows of matches (or paper strips) some were

broken (or cut) and then rearranged. The new configurations formed during the transformation consisted of "one long strip and a shorter strip forming a right angle, two equal strips set at various angles, several very short strips arranged in an arc, etc". [Piaget et al. (1960, p. 105)]. An examination of the protocols revealed several levels of subject response which were described in terms of stages. In Stage I no coordination between subdivision and change of position was found. Length of strip judgements appeared to be based on order of extremities, number of segments, or on the length of privileged segments. In Sub-stage IIA it was found that internal distortion (e.g. a non-symmetrical configuration) elicited nonconserving responses even though some conservation was present for other configurations. Thus there was an observed oscillation between conserving and nonconserving responses. Substage IIB responses revealed the beginnings of reversibility. Conservation was achieved on a trial and error basis by means of a return to the starting point either overtly or by mental processes. This stage marks the beginning of the coordination of subdivision and change of position. The complete coordination of subdivision and change of position was attained in Stage III which marks the attainment of operational conservation of length.

In Experiment Two, the measurement of length was studied by examining subject responses to situations similar to

those of Experiment One except that the subjects were asked to verify their responses by measuring the various configurations. An analysis of subject responses demonstrated a developmental sequence which was parallel to and interrelated with conservation of length. Stage I and Sub-stage IIA were characterized by an absence of the concept of unit measure and synthesis of subdivision and change of position. Some subjects counted subdivisions being uninfluenced by equality or inequality of length of these subdivisions. Thus the concept of unit (i.e. middle term) was absent. In Sub-stage IIB the subjects showed beginnings of coordination of subdivision and change of position. Thus there was some trial and error conservation. Additionally, some subjects began to understand the concept of unit and others the concept of transitivity (needed for unit iteration). In Stage III conservation of length became operational, but there was a time lag before the attainment of operational measurement. Measurement appeared in the latter part of Stage III.

From the foregoing experiments it is evident that the concepts of length conservation and linear measurement are closely related. Piaget's analysis suggests that linear measurement is possible only after the synthesis of subdivision and change of position has been achieved. There must be conservation of length as applied to what is to be measured as well as conservation of unit length before

operational measurement can emerge. Thus, while length conservation is not sufficient to insure the emergence of operational linear measurement, it is a necessary condition.

Lovell et al. (1962) carried out a replication of eleven of Piaget's experiments dealing with understanding of measurement and other concepts of metric geometry. Subjects for the study were seventy normal primary school children aged five through nine years and fifty educationally subnormal school children aged nine through fifteen years. Piagetian tasks were used in each of the experiments. For each age level, responses were categorized by Stages (I, IIA, IIB, or III) as originally done by Piaget. The results broadly confirmed the findings of Piaget. It was stated that the numbers of subjects in the various stages were not always what had been expected as compared to the information based on the Geneva children. Additionally, it was found that the operational mobility of the fourteen to fifteen year old educationally subnormal children was approximately that of the average seven and one-half year olds.

Summary

In two major experiments, Piaget et al. (1960) demonstrated the relationship between length conservation and operational measurement. Length conservation was shown to be a necessary condition for measurement. Additionally, it was demonstrated that measurement could not become

operational until the concept of unit length (or middle term) had been attained. Thus true linear measurement is possible only when a synthesis of subdivision and change of position has been achieved.

Tasks Used for Length Conservation Assessment

As noted in the previous section, Piaget used various materials and configurations of materials to assess conservation of length. Illustrations of the configurations described by Piaget et al. (1960, Ch. 4-5) are found in Figure 1 (a - i). It was also noted by Piaget et al. (1960) that both vertical and horizontal initial inclinations of rods were used. Thus several variations of the configurations illustrated in Figure 1 were possible.

Lovell et al. (1962) used tasks (a), (c), and (e) in an experiment to assess subject understanding of concepts of metric geometry. Using a stage classification of subject responses, Piaget's findings were broadly confirmed. Some variation in numbers of subjects at the various stages (compared to the Geneva subjects) was noted.

In a study of length conservation and measurement, Kamps (1971) used tasks (a) and (i) in a length conservation test with kindergarten, first- and second-grade subjects. Of the 102 subjects, 34 had the AAAS "Science-A Process Approach in grades one and two, 34 had used a Cuisenaire Rods program in grades one and two, and 34 had limited experience with linear measurement midway through

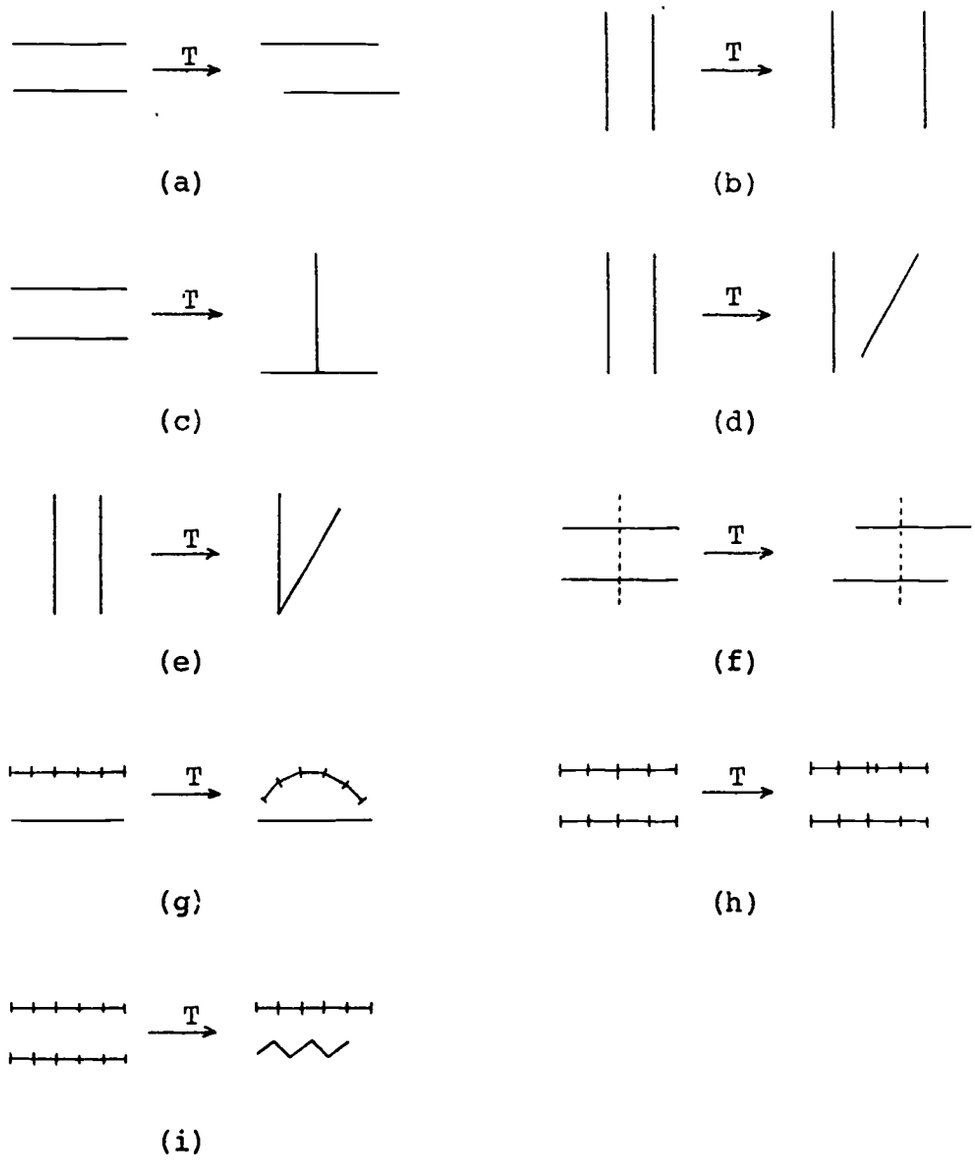

Figure 1.

Piaget's Length Conservation Tasks

grade two. The last group of subjects was reported to have the best overall performance on the conservation tasks when protocols were used to judge conservation performance.

Wheatley (1968) studied the use of conservation of number as a predictor of first-grade mathematics achievement. A length conservation task of type (a) was included. Piaget's methods were used in the assessment procedure and the results of the length conservations task were supportive of Piaget's findings.

Nelson (1970) studied the use of conservation of number and length as a predictor of first-grade arithmetic achievement. Length conservation task (a) was used and the results of the study were similar to those reported by Wheatley (1968).

Using refined techniques and materials, Wheatley and Gotto (1971) and Wheatley (1972) utilized tasks of types (a) and (d). Additionally, a task on conservation of difference of length was included in the latter study as a means of breaking possible response set in subjects.

The length conservation task used by Goldschmid (1968) in a study designed to provide normative data for conservations utilized two variations of task (a). In one case, one rod was moved to the left and in the other case a rod was moved to the right. Piagetian assessment procedures were used for all tasks of the study.

Larsen and Flavell (1970) studied the relationship between compensation and conservation in the areas of length and liquid quantity. The length conservation task was of type (b). The procedure used conservation, compensation, and conservation tasks in that order. There was no clear evidence that compensation is a developmental mediator of conservation of length.

Two of the four experiments used by Hall and Kingsley (1968) in a study of equilibration involved conservation of length. Conservation tasks used were horizontal and vertical placement of type (b) and similarly for type (d). Additionally, for type (d), unequal rods were used. In the second experiment, an adaptation of type (g) was used.

George (1970) studied the effects of amount of mathematical verbalization and rod congruency on the ability to conserve length. Both factors studied were varied in two ways. For rod congruency, either equal or unequal rods were used. It was reported that the use of unequal rods improved the ability to conserve length.

Some researchers have used length conservation tasks which are more distinct departures from the standard Piagetian tasks. Sawada and Nelson (1967) constructed an apparatus which provided three standards to be used as a basis for subject response utilizing a predicted fit of calipers. The calipers fit one standard, were too small for the second standard, and were too large for the third. Tasks involved

combinations of types (a) and (h) in that one rod or a combination of rods of various lengths were used. Rods were either solid or of pliable plasticine which could be elongated during the transformation.

Elkind (1966) and Goldschmid (1968) used both tasks of type (a) and Mueller-Lyer illusory transformations in which arrowheads were attached at endpoints of lines. Similarly, Delacy (1967) used the Mueller-Lyer illusion to study length conservation.

A more elaborate use of illusory transformations was reported by Murray (1965) in a study of conservation of length and area. For length conservation tasks, a task of type (c) was used as well as Mueller-Lyer illusory arrowheads and two-dimensional figures attached at the endpoint of lines. The other transformation used is depicted in Figure 2.

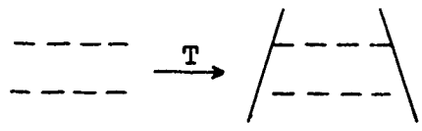

Figure 2.
An Illusory Transformation

Summary

The literature shows that most researchers have used conservation of length tasks which are very similar to those described by Piaget et al. (1960). Some researchers have used variations of the classical tasks but have not always

made a proper distinction as to what was being assessed. For example, George (1970) used unequal rods to assess length conservation while Wheatley (1972) used unequal rods as a means of breaking possible response set. Clearly, Wheatley's usage was correct in terms of Piaget's description. George's use is more correctly viewed as an understanding of length task similar to the use of one rod and a deformed string by Piaget et al. (1960). The Sawada and Nelson (1967) study and those studies using illusory transformations raise questions which are discussed later in this chapter.

Theoretical Issues

Definitional and Criterial Issues

In conjunction with Piaget's formulation of conservation, Elkind (1967) discussed a major misunderstanding which has arisen with regard to the conservation task. In classical Piagetian conservation problems, subjects were presented with standard (S) and variable (V) stimuli. Stimulus V was then transformed to yield V' in which perceptual equivalence was altered but quantitative equivalence to S was not. Following the transformation, equivalence of S to V' was to be judged. Thus, the generally used tasks are conservation of equivalence tasks in which the standard (S) is compared to the transformed stimulus V' by the subject. This means that between-object judgements are overtly made by subjects

rather than within-object judgements as implied by Piaget's definition. Consequently, two types of conservation are assessed in the generally used conservation tasks; equivalence (between-object), and identity (within-object). In this regard, Elkind noted,

> The conservation of identity, however, must always be inferred from the child's responses, whereas the conservation of equivalence is reflected directly in the child's judgements. Consequently, the conservation of identity would seem to be a necessary but not a sufficient condition for the attainment of equivalence conservation. The latter form of conservation would seem to require, in addition, the utilization of immediate past experience in the form of a deductive argument.

It was also noted, in further support of Piaget's real emphasis on identity conservation, that the three types of verbal justification used by conservers (identity, reversibility, and compensation) are really directed toward identity conservation even though the task was one of equivalence conservation. Thus, identity conservation is what Piaget's definition calls for, even though the assessment procedure used equivalence conservation as a measuring instrument.

Elkind suggested that in fact, identity conservation may appear somewhat earlier than equivalence conservation though Piaget asserted that the two forms of conservation appeared simultaneously. Elkind's position in the matter is similar to that of Hooper (1969). Hooper presumably showed that for discontinuous quantity identity conservation

is a developmental predecessor of equivalence conservation. However, because of the possible confounding of transformations, Hooper's results must be questioned.

A second definitional issue centers on the meaning of the term transformation. Piaget et al. (1960, p. 90), referring to conservation of length, stated that

> Underlying all measurement is the notion that an object remains constant in size throughout any change in position. The movement of an object appears as a congruent transformation of spatial shapes; the transformation is congruent because the length AB of an object which is moved remains identical with itself.

Piaget consistently used the terms "change of position", "movement", and "transformation" interchangeably in describing his length conservation experiments. The same consistency was evident in experiments dealing with number conservation, liquid quantity, area, volume, and so forth. Unfortunately, some researchers have not adhered closely to Piaget's formulation.

Murray (1965) hypothesized that the elimination of endpoint confusion would result in a larger number of conservers of length than found by the usual Piagetian methods. To test the hypothesis, Murray formulated seven conservation tasks which used illusory transformations. Five of the seven tasks were length conservation tasks in which the transformation consisted of placing one- or two-dimensional illusory figures at the ends of a pair of equal line segments. All tasks were administered to sixty-four subjects

who were in grades one, two, or three. Results of the test did not confirm the hypothesis.

In a similar experiment, Elkind (1966) devised tasks in which illusory transformations were used to try to show that Piaget's equation of difference theory cannot explain success on the conservation problem. Subjects consisted of sixty-eight children aged four to seven years at the Institut des Sciences de l'Education in Geneva. Test items dealt with conservation of size, form, and length. Each subject was individually tested and scores of 0 to 3 were assigned depending on the sufficiency of the explanation of responses. Results showed that the Mueller-Lyer illusion was the most difficult, but the difficulty occurred at younger age levels and the difference between it and the standard length conservation test disappeared at the stage of concrete operations. It was concluded that subjects had no more difficulty conserving across illusory transformations than across real transformations. No support was found for Piaget's equation of difference theory.

Although Elkind and Murray appeared to be in essential agreement, the question regarding the efficacy of illusory transformations still remains. It appears that, in view of Piaget's use of the term transformation, Elkind and Murray have investigated a different type or aspect of conservation. The introduction of illusory figures appears to be a form of internal distortion since there is not a congruent

transformation of spatial shapes. If this is the case, then it appears that conservation of length across illusory transformations is not equivalent to classical Piagetian length conservation at all.

Elkind and Murray are supported in their use of the term conservation by Wallach (1963). In a general discussion of Piaget's work, Wallach stated,

> The term "conservation" refers to the understanding that no change has occurred regarding one or more aspects of an object or a relationship, despite change in other perceivable features. Just as conservation of the sheer existence of objects is a slow achievement -- the notion of their multiple sensory manisfestations and their permanence despite spatial locations -- so also is the conservation, despite irrelevant changes, of other properties in terms of which we describe objects.

Clearly, Wallach made allowance in his definition for transformations which are illusory as well as those involving translations or rotations.

Smedslund (1963) made the same type of allowance for illusion in his stated definition of length conservation. He stated,

> A child is said to conserve length when he regards the length of a solid object as constant in spite of changes in apparent length due to displacements of the object and/or to alterations in its perceptual context.

Reference to Piaget's formulation suggests the inadvisability of such an all-inclusive formulation, particularly if there are to be inter-study comparisons of results. Questioning of such a formulation seems particularly

advisable in view of Elkind's (1966) finding that illusion-referenced conservation is more difficult at the lower age levels when the child may be in a transitional stage of development.

A classic example of variance in conclusions based on differing definitional criteria was provided by the Braine-Smedslund exchange. Braine (1959, 1964) and Smedslund (1963, 1965). In this exchange, Braine found transitivity of length present in four- and five-year-old subjects, but Smedslund argued that Braine's data showed transitivity emergence at seven or eight years of age. In analyzing the controversy, Gruen (1966) pointed out that different definitional criteria were used by the two experimenters. Braine used criteria consistent with Bruner's position (in which the symbolic mode becomes dominant over the iconic mode) while Smedslund's criteria were consistent with Piaget's position based on the presence of logical operations. Gruen suggested that if no mutually appropriate definitional criteria can be formulated, then each experimenter should clearly specify his criteria and the underlying psychological processes.

A second classical example of departure from Piaget's definition of conservation was provided by Mehler and Bever (1967). In this study, over two hundred very young subjects were administered tasks on discontinuous quantity conservation. Two rows of objects (M & M candies or clay pellets)

were used in each task. Prior to the transformation, both rows contained the same number of objects. The transformation consisted of adding elements to one row and then spreading the elements to form a longer row. It was concluded that subjects from (2;6) to (3;2) conserve, then lose the ability between (3;2) and (4;6), and finally reacquire the ability after age (4;6). On the basis of their findings, the investigators rejected Piaget's findings.

In criticism of the Mehler-Bever study, both Beilin (1968) and Piaget (1968) had strong reactions. Beilin was unable to replicate Mehler and Bever's results after separating the original "transformation" into its two distinct parts, addition of objects and movement. Beilin suggested that the original task was in fact a conservation of inequality task while Piaget (1968) stated that the original study had nothing to do with conservation due to the fact that there were no transformations of equal collections.

Piaget's criticism appears to be more to the point, since it is consistent with his statement regarding the congruent transformation of spatial shapes. In a later comment on conservation, Piaget (1968) iterated his view with regard to transformations. He stated that "...we can say that where there is no transformation we cannot speak of conservation". Thus it can be argued, on the basis of definition, that Mehler and Bever acted prematurely in their rejection of Piaget's results.

Hooper (1969) in a study of Elkind's conceptual distinction between identity and equivalence conservation clouded the meaning of transformation in yet a different fashion. Moderate and extreme transformations were used to examine the influence of perceptual cues on subject response. These transformations were defined by the dimensions of the containers used in the conservation of discontinuity task.

It may be questioned whether Hooper actually defined levels of transformations or whether, in fact, he attached labels to perceptual cue strengths which were results of the transformations. Piaget's use of transformation suggests that the second possibility is the more probable of the two.

When a child has attained a conservation concept, he is viewed by Piaget as having structures which are in a state of equilibrium. This state has been achieved via the process of equilibration. As noted previously, some researchers have not followed Piaget's definitional criteria of conservation. From later experiments by other researchers there has also arisen considerable variation in the criteria used to assess conserving behavior.

In an experiment undertaken to try to explain some of the inconsistencies in replications of Piaget's experiments on conservation of number and in reported results of later training studies, Gottfried (1969) introduced a new criterion for conservation assessment. Contrary to assumptions of previous investigators, he assumed that both number

properties and length must be considered relevant to the child. Consequently, Gottfried developed a compound number-length task in which the child manipulated one variable while controlling the other. This was accomplished by means of an electrically powered apparatus on whose screen appeared a row of red-lighted squares. Length of row or number of squares were manipulated by the child using one of two switches. In addition to the theoretical criterion, the performance criterion for success was fifteen successive correctly anticipated operations. A maximum of 150 trials or thirty minutes was allowed each child. Results indicated among other things that performances on number conservation were far superior to that for length conservation for both solvers and nonsolvers of the compound problem and that length conservation was more relevant than number conservation to the solution of the compound problem.

The Gottfried study may be seriously questioned with regard to both of the criteria which were introduced. It appears that to form a compound task in terms of number and length conservation is to confound the conservation problem since the investigator apparently applied length conservation to discontinuous quantity. Thus it appears that Piaget's distinction between distance and length was ignored. Additionally, other research has generally supported Piaget's view that while number and length conservation have a parallel development, length conservation is attained

somewhat later than number conservation. Hence Gottfried's findings are not unexpected. The second criticism deals with the performance criterion of success. Since only fifteen successive correct trials were required, a child could conceivably be classified as a solver (conserver) and yet be performing well below the seventy-five percent level normally used. This is quite different from Piaget's definition of an operational conserver.

In addition to questioning the criteria used by Gottfried, a more fundamental criticism may be made. Brainerd (1970) suggested that the assumption of essentially similar cognitive demands by the various conservations may not be tenable. He suggested that some of the problems presently encountered in Piagetian research on the conservations imply the need for an alternative to the continuity hypothesis which is based on the "... inference that there are meaningful dissimilarities in the specific conceptual requirements of conservation problems and the assertion that similarities among these tasks are more apparent than real."

Beilin (1965) in a training study on conservation of number, length, and area pretested subjects on conservation of number and length utilizing a different conservation criterion. This criterion consisted of two components; performance criterion and verbal explanation criterion. In the pretest, there were two practice trials and twelve trials

each with a number and length component. If correct responses were given in five of the last six trials the child was classified as a conserver on the performance component. Similarly, one correct or zero correct out of the last six trials gave a performance classification of transitional or nonconserver respectively. The verbal component was scored accordingly.

The performance criterion in the Beilin study is open to question because of the fact that only ten of a possible twenty-four responses were required for a conserving classification. Even if the explanation criterion is added it would still be possible for a child operating at less than the seventy-five percent level to be classified as an operational conserver. Additionally, it was possible for a child to correctly perform on one of twelve trials (both performance and explanation criteria taken into account) and yet be assigned in the transitional stage. If only verbal explanation, as opposed to justification, was used, the transitional stage could have been attained on a chance basis.

Referring to the types of criteria previously discussed, Goldschmid (1967) discussed patterns of nonconservation discernable in his study. He stated,

> ... it can be concluded that the level of conservation found in a given age group may be related not only to a particular conservation task as has been amply demonstrated by Piaget and others, but also to the number and variations of trials employed to measure that particular content area of conservation.

Later in the same discussion Goldschmid continues, "Thus different trials employed to measure the same content-area of conservation may reveal conservation to a very different degree". Goldschmid's view was supported by Rothenberg (1969) in which she found considerable variability of conserving behavior across the number of transformations used.

Summary

The literature reviewed demonstrates the existence of definitional and criterial issues which have arisen from studies of Piagetian conservations. These issues appear to center on the meaning of the term transformation and on criteria used to define conserving behavior during the assessment procedure itself. Specific criterial issues which have been identified are real versus illusory transformations, number and type of transformations, performance criterion, and explanation criterion. The latter criterion is of sufficient importance that it is discussed separately in the following section.

Verbal Versus Nonverbal Conservation Assessment

Perhaps the single most discussed issue in conservation assessment has been Piaget's use of the criterion of verbal justification of responses by the child during the assessment procedure. That Piaget considers this indispensable is amply documented by his use of the interview

technique as well as the numerous protocols provided in published accounts of his experiments on intellectual development.

The discussions which follow presentation of the protocols, Piaget et al. (1960), demonstrate Piaget's view that only through a consideration of a child's justification of his responses can the true level of conservation attainment be accurately judged. In a critical review of some of Bruner's positions on cognitive development, Piaget (1967) supports his own view by citing work of one of his colleagues, Sinclair, who showed that a child's language is transformed along with the construction of operational structures. Piaget further stated, "Verbal training, however, results in progress in conservation with only 10% of subjects, though after such training 65% of subjects show a grasp of co-variance of dimensions". Since Piaget distinguished between co-variance of dimensions and compensation, it is implied that even though 65% of subjects grasped co-variance of dimensions, these subjects were unable to synthesize the relations into an operatory structure.

Goldschmid and Bentler (1968) are in essential agreement with Piaget with regard to the assessment of conservation. They noted that in the assessment procedure, conservation behavior or testing for comprehension of conservation principles, or both, is a necessity. Additional evidence that subject explanation of responses is a viable criterion was provided by a study in which Goldschmid (1968) attempted

to develop conservation scales. The purpose of the study was to introduce psychometrically sound measures which would facilitate the refinement of the assessment and evaluation of Piaget's theory. Correlations between conserving behavior and verbal explanation were generally in the low .90's.

Similarly, Smedslund shares Piaget's position regarding response justification as evidenced by the Braine-Smedslund exchange.

Gruen (1966), by reanalyzing the data from an earlier experiment [Gruen (1965)], reached the conclusion that the criterion of response explanation is more stringent than a criterion which does not require explanation.

Shantz and Sigel (1967) indicated that the introduction of false positives into accepted responses can be avoided if a logical justification is required as part of the criteria for determining conserving behavior. However, Rothenberg and Orost (1969), in noting the Shantz-Sigel position, stated

> ... it is felt that, for the purpose of these studies the use of two similar but differently phrased questions about each of five test transformations provides a sufficiently stringent criterion for assessing conservation.

In conjunction with the altering of the verbal criterion by Rothenberg and Orost, the results of an experiment by Mermelstein and Shulman (1967) cast further doubt on the efficacy of the verbal explanation criterion. The object of the experiment was to study the effect of schooling,

differences between verbal and nonverbal assessment, and variation of question types in verbal tests on conservation. Subjects were individually tested on conservation of continuous and discontinuous quantities. Responses were categorized into Piagetian Stages 1, 2, or 3 by raters having 90 percent agreement. Evidence indicated that presence or absence of language itself significantly affected performance, questions which stress more than one event may convey ambiguity to subjects, and the type of question may affect performance.

Other researchers have apparently been unconvinced of the efficacy of verbal techniques of conservation assessment both from the point of view of subject verbalization and the issues associated with the component factors. Braine (1959) was very specific in questioning the use of verbal techniques of conservation assessment. In his criticism of Piaget's techniques, he stated,

> No theory which postulates levels of conceptual development can be regarded as definitely established when the supporting data are obtained through extensive verbal communication with Ss who differ in their ability to verbalize.

Subsequently, some experiments have been conducted utilizing nonverbal assessment techniques. There appear to be two assessment techniques which may be referred to as nonverbal. One is characterized by nonverbal subject responses and the other by an absence of terms which are synonymous with the content to be assessed. The latter appears to be

the more generally accepted of the two. [Murray (1970), Sawada and Nelson (1967), and Silverman and Schneider (1968)].

As previously reported, Murray (1965) used illusory transformations in a test of length and area conservation. Subjects reponded to verbal questions by using paper and pencil. Hence this was a nonverbal assessment of conservation in the sense that no verbal justifications were required of the subjects. However, the larger numbers of conservers expected by Murray did not materialize and consequently Piaget's criterion of verbal explanation could not be challenged.

Later, Murray (1970) used two verbal and two nonverbal tasks to study conservation of illusion-distorted length. Sensitivities of the various measures to detecting conservation were determined. It was concluded that it appears feasible to construct other operational definitions of conservation which possess some construct validity and which have different levels of sensitivity to conservation.

Sawada and Nelson (1967) constructed a length conservation test which was nonverbal in the sense that verbal symbols used to communicate the property of length were eliminated. After training each subject in the use of the calipers, a rod or set of rods was placed before the subject. The subject applied the calipers and then the experimenter transformed the rod (or rods). After the

transformation the subject was asked to predict how the calipers would fit if he were allowed to apply them again (when compared to model fits on the apparatus used in the experiment). Results indicated the threshold for length conservation to be at approximately five to six years of age, some two years earlier than indicated by Piaget. It was concluded that assessment techniques which are highly verbal may interfere with the child's ability to express his understanding of the length conservation concept to such a degree that he is classified as a nonconserver.

It should be noted that in both the Murray and Sawada-Nelson studies the transformations used did not always conform to Piaget's criterion. In the former, illusion was introduced while in the latter, the plasticine rod was actually changed in length by rolling it. Thus perhaps some of the conclusions regarding length conservation should not have been made on the basis of Piagetian conservation.

Using the term nonverbal assessment in a fashion similar to Sawada and Nelson, Silverman and Schneider (1968) studied conservation of discontinuous quantity in 147 subjects aged four to ten years. Data revealed an increase of conservation with age, but only 80 percent of the nine-year-olds conserved. Two aspects of the results of this study raise serious questions. First, the one conservation task used was conservation of difference since the original equal beakers contained different amounts of candies. Also,

because of the task used, one would have expected higher levels of conservation. The second question deals with the criterion of success used. The subject had to choose the jar with more candy, correctly respond to which jar had more candy, and indicate that he chose it because it had more -- and yet the test was nonverbal in the sense that choice of jar did not depend on the subject's use of the terms "more" or "less".

Wheatley and Gotto (1971) have made what may be regarded as an important contribution to the solution of the verbal-nonverbal assessment of conservation issue. In this experiment both individual and group forms of a conservation test were administered. By the use of motion pictures and synchronized audio tape for the group form, conservation scores were obtained which correlated highly with scores from the equivalent individually administered test using concrete materials and subject explanations.

In a further elaboration of the film technique by Wheatley (1971), comparable scores were attained which demonstrated the applicability of the film tests across grade level and cultural background.

The Use of Relational Terms. Some of the assessment procedures, whether verbal or nonverbal have involved the use of relational terms such as "same", "more", "less", "longer", "shorter", and so forth.

In an experiment by Rothenberg (1969), number conservation among four- and five-year-old children was studied. It was concluded from the data obtained that the understanding of key words was incomplete and that such understanding should be assessed in conservation tests.

Griffiths et al. (1967) studied the use of the relational terms "more", "same", and "less" in subject comparisons of number, length, and weight of objects. For length comparisons, the terms "longer" and "shorter" were substituted for "more long" and "less long" respectively. Analysis of variance showed a significant difference among relational terms ($p < .01$) and among content areas with significant interaction between content area and relational terms. In particular, subjects used "more" and "less" (i.e. "longer" and "shorter") correctly more often for length than they did the term "same". Of the content areas, subjects had least difficulty using any relational term with length comparisons. In agreement with Rothenberg (1969), it was suggested by the experimenters that the understanding of relational terms be assessed prior to testing for conservation attainment. It was also suggested that the structure of the question asked by the experimenter may determine correct or incorrect usage of terms in a specific content area.

In an attempt to determine the extent to which language is a factor in number conservation assessment, Fletcher (1967) used an operationally defined relational term,

"bimates". Two hundred first-grade subjects were divided into two groups and both were trained on the operational use of "bimates". In the testing, one group received the bimates terminology and the other group was tested with the use of the standard relational terms. No significant differences were found between the responses of the two groups.

Semantic differential judgements of relational terms were studied by Harasym et al. (1971). Using first, second, and third grade subjects it was found that logical conservers see "more" and "less" as opposites, intuitive conservers see "more" and "less" as different but not opposite, and nonconservers confuse the two terms. These findings led the experimenters to suggest that the meanings of quantative relational terms evolve parallel to the acquisition of conservation.

Summary

A consideration of Piaget's use of verbal explanation in the assessment procedure by other researchers has led to considerable discussion. Some researchers take the Piagetian position that the true level of conservation can be assessed only by questioning and probing the subject responses using additional questions. The literature also suggests the possibility of introducing false positives if explanations are not required.

On the other hand, other researchers point out that question structure may introduce systematic bias in results

by means of unintended cues and that requiring subject verbalization may mask an underlying understanding of the conservation concept. However, it is suggested that the use of similar but differently phrased questions may provide a control for systematic bias and admission of false positives.

Some researchers have introduced nonverbal measures of conservation as a means of avoiding the possible weaknesses of verbal assessment techniques. In so doing, departures from the Piagetian definition have sometimes been evident with the result that stated conclusions must be questioned. However, recent work, notably by Wheatley (1971, 1972), may provide a break-through in assessment procedures which will at least give a partial solution to the issue surrounding verbal and nonverbal assessment of conservation.

In both verbal and nonverbal assessment procedures, relational terms have been used. It has been demonstrated that meanings of these terms vary from child to child. Thus it appears that relational terms constitute an important factor which must be taken into account whether the assessment procedure is verbal or nonverbal.

Situational and Methodological Variables

Situational variables include the materials used to test for attainment of conservation. These apparently include the physical properties or composition of the objects to be transformed during the assessment procedure. For example, one could have rods made of styrofoam, wood,

candy, paper strips, or even line drawings to be used for a conservation of length task. Some of the methodological variables deal with the implementation of the conservation definition in the assessment procedure. The methodological variables include the types, number, and nature of the transformations used in testing for conservation attainment.

Uzgiris (1964) investigated the influence of situational variables on the sequence of development of conservation of substance, weight, and volume. The subjects for the study were 120 parochial school children. Scalogram analysis indicated that the order of attainment of these conservations was substance, weight, and volume, in that order. It was further suggested by the results that a relation between situational variables and conservation behavior may be most evident during the formation of a conservation schema. It was suggested by the investigator that a second approach to the understanding of observed situational variability is to look for broader classes of variables under which groups of different variables would be subsumed.

It seems reasonable that situational variables may influence subject responses during the formation of a conservation schema, since at this stage the necessary logical structures are in a final stage of formation. Thus the subject can be expected to be influenced by some irrelevant cues because the structure which would override them is not yet completely functional.

Zimiles (1963) commented on the number conservation and nonconservation choices by subjects of a study by Wohlwill and Lowe (1962). In the latter study it was observed that if subjects count a set of buttons, then estimate the number of buttons after they have been pushed together, many subjects state that there are more buttons following the transformation. On the other hand, if the buttons are in rows with buttons in one row then spread apart, many subjects now state that the longer row has more. Zimiles suggested that in spite of the apparent contradiction between the two situations, the common feature was that the decisive cue in both instances was the change introduced by the experimenter.

Later, Zimiles (1966) conducted two experiments to assess the development of conservation and differentiation of number. While none of the hypotheses of the study were supported, some revealing information was found by studying the reasons for failure on the part of the nonconservers. The information suggested that the essential feature of the conservation procedure is noting the conflict in the rearrangement of the relevant and irrelevant cues by means of the transformation. It was suggested that the principal element in the assessment procedure is that the subject recognize the irrelevance of the transformation and be unaffected by it.

Wallach et al. (1967) reached the same conclusion as Zimiles. They stated "Conservation cannot be attained when a cue for nonconservation is relied on... . We believe, therefore, that in order for a child to conserve, he must both recognize reversibility and not rely on inappropriate cues."

Some interesting conclusions regarding cues were also reached by Hall and Kingsley (1968) in four experiments designed to provide information for a study of Piaget's equilibration theory. Two of the experiments utilized length conservation tasks. Experiment 1 used young subjects and Experiment 3 used upper class psychology students. General conclusions reached were that instructions are just as important as the visual appearance of the objects and that adults do not conserve typically as well as hypothesized by the theory. In particular, for young subjects it was that because they wish to be correct, subjects may pay more attention to the experimenter than to objects being manipulated. Additionally, it was suggested that by questioning how the child can tell if rods are the same length or not (similarly for the other conservations), the experimenter may be introducing a systematic bias into the results.

In an experiment to determine the relationship between perception dominated thinking and logical thinking, Halpern (1965) hypothesized that the supremacy of misleading perception is a function of an empirical orientation (i.e.

reasons based on observable attributes) during the concrete operational stage. Subjects were five to seven years old and were classified as empirical or deductive by means of their approach to screening problems. Results indicated that in the stage of concrete operations, if problems provided both perceptual and logical cues the empirically oriented subjects erred significantly more often than those subjects having a deductive orientation. In addition, in such problems the empirically oriented subjects made more of their errors where perception directly contradicted logic as opposed to those with deductive orientation. These results led the experimenter to conclude that the dominance of misleading perception continues into areas in which there is concrete operational thinking present. Thus it was concluded that even in the presence of operational structures, perception can govern thinking.

While some experimenters have investigated the role of perceptual cues which may be functions of the transformations used, others have concentrated their efforts to identify and study other methodological variables which may influence subject responses. Rothenberg and Courtney (1969) analyzed various types of transformations used in number conservation tasks to try to determine those aspects of transformations which are attended to by nonconservers. The transformations were not specifically designed to separate out the importance of the factors of length, density, manipulation, and closeness of a row of discs to a subject. However, some tentative

conclusions were reached for subjects aged (4;3) to (6;2). Length of a row was found to be most important in the choice of a row with "more". It was also suggested that the factors of manipulation, closeness, and density, in that order, seem to influence the nonconserving choice.

The investigators indicated that more attention should be given to the factors of closeness, manipulation, and other possible influences. Secondly, they suggested that the influence of these factors in differing types of transformations should be studied using items specifically designed to separate out the effects of these factors. Rothenberg and Courtney went on to note that such studies would lead to a more methodologically sophisticated investigation of children's concepts of conservation and provide an advance in the theory of cognitive development.

In another study, Rothenberg (1969) investigated the effects of focus and number of questions asked, presentation of various transformations, and the use of justifications of prior subject judgements on conservation of number status. The subjects were 80 pre-school children and 130 kindergarten children. All subjects were individually tested on five number conservation tasks using the standard Piagetian format. Each task involved a different transformation. Results showed an incomplete understanding of key words, and there was considerable variability of conserving behavior across the number of transformations used. The

investigator suggested that true conservation status cannot be determined reliably on the basis of one or two types of transformations and that more types would result in a more accurate picture. It was also suggested that the order of questions should be varied to control for the effect of recency on subject responses.

Regarding the variability of conserving behavior across the number of transformations, it is of interest to note that while 92 subjects conserved on at least one transformation, only 31 conserved on at least three transformations and only 13 subjects did so on all five. Thus, apparently the type and number of transformations have a direct effect on the ability to conserve.

In a study of ten Piagetian tasks and their relation to age, sex, IQ, MA, and vocabulary, Goldschmid (1967) found a positive correlation of conservation with the latter measures. An analysis of nonconserving responses suggested an interaction between frequency and type of nonconservation on the one hand, and the particular task and configuration of the manipulated object on the other. The investigator noted that different trials employed to measure the same content area of conservation may reveal very different degrees of conservation. He suggested that the level of conservation measured may be a function of the particular transformation of the objects as well as a function of the task involved. It was also noted that certain configurations of stimuli may

be perceptually more compelling than others, and that all of these possibilities should be systematically analyzed.

The effects of four training methods on conservation of number, length, and area were studied by Beilin (1965). Results indicated that although all four methods were effective for number and length, there was no transfer to area.

Of particular interest, in view of Rothenberg's study (1969) was the sample length conservation task. (See Figure 3).

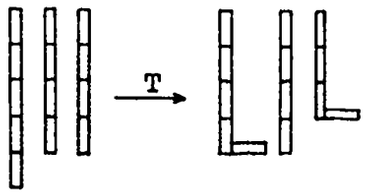

Figure 3.

Beilin's Three-Rod
Conservation Task

It was not stated by the investigator whether the transformation was composed of a simultaneous or sequential movement.

Similarly, in another training experiment by Gelman (1969), subject attendance to relevant attributes was studied. Three training conditions were employed. For the length conservation tasks used in one training method a three-rod configuration was used. Rods were arranged so that "same" choices could be made on the basis of length (relevant) or end-matches or parallel cues (irrelevant).

No mention was made of a transformation, however the introduction of a third rod was somewhat novel. A sample task with arrangements is shown in Figure 4 (a - f)

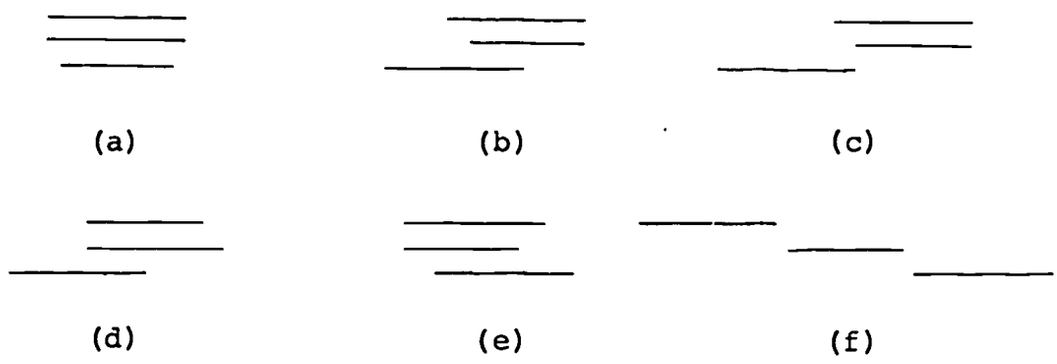

Figure 4.

Gelman's Three-Rod Conservation Tasks

Shah (1969) used student teachers to instruct subjects on content in "modern geometry". Lessons based on Piaget's concepts of reversibility and invariant object properties, were presented to 374 subjects aged seven to eleven years. Lessons included the rotation of figures about a point and translations. In the final test each of the eight content areas was covered with the testing time varying from seven to twenty-five minutes for each area. The reliability of the test was .93 and though performance increased with age, the areas of rotation and translation produced some interesting data. Of the subjects in the 8-9 age group, 48.1 percent were at or below threshold on rotation and 66.4 percent were at or below threshold on translations. Further, the mean scores were 10.8 (out of 20 possible) on

rotation and 3.4 (out of 8 possible) on translations for the 8-9 age group. Even though the final test was not a test of conservation, it appears that transformations which involve rotations or translations need further study.

Additional variables affecting subject responses were identified by Bittner and Shinedling (1968) in a test of substance conservation. In experiments with first- and third-grade subjects, it was found that sex of experimenter was a significant variable. First-graders responded best for female E's while third graders responded best for male E's. Also, form effect was significant for grade three subjects. Form was defined as the same set of questions grouped in different orders. In discussing their findings, the investigators recommended that further experimental consideration be given to the variables of sequence, sex of S, sex of E, and their interactions at each age level. Because of the small sample used in the study, the conclusions reached should be regarded only as tentative until further work is done in the area.

Summary

Of major importance for conservation assessment are methodological variables which have been identified. Among these variables are perceptual cues which may be the results of transformations or stimuli configurations, number of transformations, type of transformations, or relative empirical-deductive subject orientation. The number of

studies dealing with these variables is rather small in comparison with those relating to the other issues previously discussed. Thus, it is suggested that these variables should receive closer scrutiny. In particular, little attention has been focused on the effects of type of transformation and planar orientation on subject responses. The latter is clearly a delineation of the number of transformations and perceptual focus variables. Thus in addition to number and types of transformations, possible interactions should be studied.

In his discussion of scientific investigations, Nunnally (1967) suggested that as evidence accrues from the work of several scientists interested in a particular construct, it would be fruitful to attempt to specify the domain of related variables even though in general no precise method can be given for outlining them.

Group Testing of Conservation

Aside from the theoretical issues which have arisen with regard to definitional abuse, verbal-nonverbal assessment, and methodological variables, a question has arisen regarding the possibility of the use of group testing to assess conservation. Two aspects which have prompted the investigation of the question are appropriate tests to determine readiness and the need for adequate predictors for achievement in elementary mathematics. In either case, the efficiency of test administration is of great importance.

Becker (1969) determined the reliability with which selected individual tests of language, visual and auditory perception, and auditory-visual perception integration can be administered through the use of group testing. Four tests were used in this study; the Peabody Picture Vocabulary Test (PPVT), Bender Visual Motor Gestalt Test (BVMGT), Sabatino Test of Auditory Discrimination (AD), and Birch Auditory Visual Integration Test (AVI). These tests were individually administered to 169 subjects in grades K through 3. Fifteen days later the subjects were group tested. The reliability varied according to age groups, but data for the six- and seven-year-olds indicated that group screening programs can give reliable perceptual-motor data as early as grade one. Additionally, low positive correlations were found to exist among the BVMGT, AD, AVI, and PPVT which suggested that different behaviors were being assessed by the group testing technique.

Among the earliest to investigate characteristics of a group test based on Piagetian principles was Dodwell (1961). This test contained five items; one each on relation of perceived size to number (conservation), provoked correspondence, unprovoked correspondence, seriation, and cardination and ordination. All items on the group test consisted of drawings which depicted initial and terminal states, but not transformations. The individual test contained similar items except that subjects witnessed the transformation.

Initially the group test was correlated with arithmetic marks of grade one children. These correlations ranged from -.05 to .56. On this basis, Dodwell suggested that term marks are not a good criterion measure with which to validate the number concept test. He further commented that because the term test in arithmetic measured performance in rote learning, it had little relationship to his group test.

Next, Dodwell gave 40 kindergarten children the group test during their final term in kindergarten and followed this with a teacher-made arithmetic achievement test at the end of the first term of first grade. The correlation between these two tests was .59.

To determine the degree of relationship between individual and group forms of the number concept test 68 children in grades K, 1, and 2 received the individual form followed by administration of the group test. The correlation between group and individual scores was .68. Dodwell felt this correlation was relatively high but suggested that further experimentation would be desirable.

Delacy (1967) designed a paper and pencil group test of length conservation. Each of the four conservation tasks used two three-inch lines drawn on paper. Mueller-Lyer illusion arrowheads having various degrees of opening were superimposed as the transformation. The 140 subjects of the study ranged in age from six to twelve years. Subjects were individually tested even though the test was designed as a

group test. The results were discouraging due to the small proportions of conserving behavior at several age levels and also because of a substantial inversion which occurred amongst the ten-year-olds. On the basis of the data, Delacy concluded that children cannot reliably conserve until twelve years of age. The use of illusion in the Delacy study may be a contributing factor to the discouraging results. The conservations measured may in fact be much different from the classical Piagetian conservations because of the difference in definitional interpretation.

Kaminsky (1971) investigated the feasibility of using a group test for measuring conservation attainment and assessed the relationship of conservation development to arithmetic achievement. The Lorge Thorndike Intelligence Test (LTIT) and Stanford Achievement Test (Arithmetic) (SAT) were administered to 180 subjects in grades 2 and 3. The group administered concept test contained 18 four-item concepts similar to tasks which Piaget administered to the subjects in his experiments on conservation attainment. The concept test, adapted from the work of Freyberg, in New Zealand, was not validated with individually administered tests. However, for the original concept test, Freyberg found an internal consistency coefficient of .87, a test-retest reliability of .91, and a validity coefficient of .91. Correlations between the concept test and the LTIT and SAT were .23 and .81 respectively. These correlations were significant at the .01 level.

Wheatley and Nelson (1968) studied a group static conservation test (GT) and compared this instrument to an individual manipulative conservation test (IT). Test groups were GT-IT, IT-GT, IT, GT, and control. Data revealed no influence of GT on IT nor IT on GT performance. The GT correlated .57 with the IT, but the researchers concluded that the coefficient was too low to claim validity for the GT because of the fact that static conservation items were used on the GT. Additionally, since the GT and IT had respective correlations of .25 and .45 with achievement, it appeared that the GT and IT might be measuring different concepts. For the GT-IT and IT-GT test groups, analysis of the data on the one length conservation item revealed that there was 81 percent agreement between subject responses on the two tests. Thus it was concluded that further research in group test design was warranted.

Nelson (1969) developed a group test of number and length conservation. The ability of the group test to predict first-grade arithmetic achievement was studied. The group and individual tests were based on the Number Concept Test developed by Wheatley (1968). The GT consisted of twelve items; seven on number conservation, four on length conservation, and one item on understanding of the term "more". The IT consisted of sixteen items; nine on number conservation, two on length conservation, and five on understanding of number. Fifty-three subjects received both the

GT and IT. Administration of the GT was by overhead projector. Results indicated that in sequential administration IT did not influence GT performance but that GT did influence IT performance. IT-AT, GT-AT, and GT-IT correlations were .46, .43, and .51 respectively. It was concluded that the GT demonstrated both content validity (by comparison to the IT) and predictive validity for first-grade arithmetic achievement. However, it was suggested that attempts to improve the GT are warranted.

Wheatley and Gotto (1971) undertook a much more comprehensive experiment to ascertain to what extent group testing of Piagetian conservation concepts is feasible. The test contained items on conservation of number, length, substance, and discontinuous and continuous quantity. Of 148 first-grade subjects, all received the group test and 40 received the individual test. Each test consisted of 23 items. For the individual test concrete-manipulative involving transformations were used. The group test used a motion picture film presentation. Responses were marked by the examiner for the individual test and by the subject for the group test. Reliabilities of .96 and .91 were reported for the individual and group tests respectively. The correlation of the two forms was .86. Since the only difference between the tests was the manner in which they were presented, it was concluded that the group test used in

this study is a feasible way in which a child's ability to conserve can be assessed.

Using an improved and extended version of his previous group test, Wheatley (1972) administered a group film conservation test to 1400 subjects of varying ethnic, socioeconomic backgrounds, and grade levels. Although intact classes were tested because of design requirements, the results of the 1971 study were generally supported. Additionally, this test was shown to have high internal consistency, culture fairness, and low positive correlations with intelligence and achievement measures. Thus in addition to measuring concept formation (conservation attainment) reliably, the low positive correlations with other measures indicated that what was being assessed was different from that measured by other commonly used tests of intelligence and achievement.

Summary

A small but growing body of literature demonstrates the feasibility of group testing for conservation attainment. In particular, the systematic development of group administered conservation tests by Wheatley and his students has demonstrated that difficulties in such test design can be overcome and that reliable instruments possessing content validity can be constructed. The efficiency of such instruments has been amply demonstrated. Additionally, such instruments enhance the possibility that at least some of

the methodological variables, mentioned previously, can be efficiently studied. From a more practical view, such group tests could provide an efficient means for the assessment of readiness of the child to study given concepts in a meaningful fashion or identify the need for suitable experiences which will facilitate the child's intellectual development.

General Summary

A review of literature revealed that in addition to maturation, experience, and socialization, an additional factor was needed to explain the process of intellectual development in children. Piaget hypothesized an equilibration factor for this purpose and in a series of experiments found evidence to support such a factor. The gradual formation, through a distinct sequence of steps, of a logical necessity for reversibility of transformations on objects was observed. Piaget regarded the advent of logical reversibility, which resulted in conservation attainment, as the distinctive characteristic exhibited by a child when entering the stage of concrete operations. Since it was confirmed by experimental evidence that reversibility led to conservation, the latter could be taken as a criterion for entrance to the concrete-operational period.

In addition to the confirmation of the equilibration factor, experimental observation revealed that the process

of equilibration consisted of four distinct steps leading from centration on a specific attribute of an object to a gradual acquisition of reversibility of an accompanying transformation. The latter became possible through a process of decentering in which the role of transformation, and its irrelevance to change in object attribute, was attended to rather than centering on states of objects.

Various tasks were designed by Piaget and his colleagues as a means of studying the conservations which play a role in the development of mathematical concepts. One sequence of tasks, used in the study of length and measurement concepts, revealed that the two concepts have parallel developments, but that measurement cannot become operational in the Piagetian sense until there is a synthesis of subdivision and change of position. This involves the concept of unit length used as a middle term in the measuring act. Consequently, underlying all linear measurement is the realization that both the length of the object to be measured and that of the object used to measure must be conserved. Because of this, the concept of length conservation is basic to linear measurement.

Experiments by other researchers have resulted in a number of questions being raised both with regard to Piaget's theory and his experimental procedures. One issue revolves around the definition of conservation and appropriate criteria to be used in defining conserving behavior.

While the latter may be a viable issue, a review of the literature suggests that definition should not be an issue. The literature suggests rather strongly that most of the researchers who have raised the issue did not use Piaget's definition, but rather an altered formulation which of necessity was influenced by their own theoretical positions regarding intellectual development. Consequently, that which was being assessed may well have been different from the concept formation assessed by Piagetian conservations. Braine, Bruner, Murray, and others exemplify such differential formulations.

Much of the current discussion which questions the verbal assessment techniques used by Piaget has led to experiments which revealed several variables which were not adequately controlled in Piaget's experimental work. Among these variables are non-standardization of questions asked, the use of relational terms and their differential comprehension by subjects, and of major importance, the fact that requiring response justification may require a verbal facility not yet attained by younger subjects. Thus, verbal assessment procedures have become a major point of contention. The work of Wheatley and Nelson appears to provide a major breakthrough in assessment procedures. In particular, Wheatley has systematically studied the problem and designed group administered tests which can be used to measure conservation ability of children. These tests appear to have

content validity and high reliability relative to individually administered tests even though response justification is not required. Thus, the feasibility of group testing procedures for conservation attainment has been established.

Group testing procedures appear to be a promising approach to the study of other theoretical issues which have arisen with regard to Piaget's work on conservation. Several of these issues have arisen due to the identification of methodological variables which may influence subject responses. One of the prime variables is perceptual cuing which may result from stimuli configurations and transformations used. A number of researchers have called for a systematic study of these methodological variables. Beilin, Gelman, Rothenberg, and Shah have introduced substantial refinements into stimulus configuration and transformation aspects. However, there has been no careful study of the effects of orientation sequence and transformation-produced perceptual focus on conservation responses. It appears that these variables could be efficiently studied by use of a group testing procedure.

CHAPTER III

PROCEDURES

The main purpose of this study was to investigate the effects of perceptual focus and planar orientation of rods on length conservation responses when parallel translations of the rods were utilized. Previous research had suggested that these methodological variables should be investigated and that further work on the construction of group tests which could adequately test the same concepts as individually administered tests of conservation was warranted.

Hypotheses to be Tested

In order to examine the objecti es of the study, as stated in Chapter I, the following null hypotheses were formulated and analyzed.

Hypothesis I(a): There are no significant differences in numbers of conserving responses measured by COL8-2 and COL8-3.

Hypothesis I(b): There are no significant differences in the number of conservers at the 100 percent criterion level as measured by COL8-2 and COL8-3.

Hypothesis II(a): The sequencing of planar orientations has no significant effect on conservation of length responses as measured by COL8-2.

Hypothesis II(b): The sequencing of planar orientations has no significant effect on conservation of length responses as measured by COL8-3.

Hypothesis III(a): There are no significant effects on conservation responses which are due to practice when multiple items of a similar nature are presented to subjects by means of COL8-2.

Hypothesis III(b): There are no significant effects on conservation responses which are due to practice when multiple items of a similar nature are presented to subjects by means of COL8-3.

Hypothesis IV(a): There are no significant differences in length conservation responses between male and female subjects as measured by COL8-2.

Hypothesis IV(b): There are no significant differences in length conservation responses between male and female subjects as measured by COL8-3.

Hypothesis V: There are no significant differences in the numbers of second-grade operational conservers of length when COL8-2 is administered by male and female examiners.

Hypothesis VI: The expectancy of the test administrator has no significant effect on the numbers of second-grade operational conservers of length as measured by COL8-2.

Hypothesis VII(a): There is no significant correlation between responses on the group conservation of length test COL8-2 and the ICT.

Hypothesis VII(b): There is no significant correlation between responses on the group conservation of length test COL8-3 and the ICT.

Statistical Design of the Study

Since neither of the methodological variables, perceptual focus nor planar orientation sequences of rods, had been adequately investigated, it was concluded that possible interaction between the two variables should be examined. Consequently, the study was structured around a factorial design. Four orientation sequences were formulated such that each one of the orientations 0°, 45°, 90°, 135° formed the first term of exactly one sequence, the remaining orientations being randomly selected. The purpose for such a construction of sequences was to assure the presence in the experimental design of one sequence from each of the four groups of sequences which could be formed by permuting the four selected planar orientations. Thus, the planar orientation sequence variable had four levels. These sequences are detailed in "Definition of Terms Used" in Chapter I. The perceptual focus variable had two levels; one characterized by movement of one of two rods and one in which two of three rods were moved simultaneously in opposite directions. Hence the statistical design used was a 4 x 2 factorial analysis of variance design by means of which main effects of the variables could be tested as well as possible

interactions between levels of the variables. The design is illustrated in Figure 5.

Planar Orientation Sequence	Perceptual Focus	
	One rod moved	Simultaneous movement of two rods
1		
2		
3		
4		

Figure 5. Statistical Design Schematic

The Sample and Testing Schedule

Selection and General Characteristics of Sample

The subjects of the study were second-grade children enrolled in the Logansport elementary school system and third-grade children enrolled in the Peru elementary school system. The cities of Logansport and Peru are midwest communities in Indiana with respective populations of approximately 19,000 and 15,000. The economies of both communities are based on some light industry and agriculture. The Logansport system maintains no records regarding the SES of

its students, however the SES was described by school officials as largely middle class except for two schools of the study which were described as primarily lower middle class with more lower class SES students than the other schools of the system which were a part of the study. For the Peru system, only partial SES records were available since not all elementary schools had school lunch programs. However, school officials did estimate the percentages of students who would qualify for a low SES for total elementary school populations by school. When this data was combined it was found that approximately fifteen percent of the elementary students were estimated to be of low SES. Percentages of low SES students by school ranged from approximately five percent to as high as eighteen to twenty percent.

In order to test hypotheses, schools having two classes of second-grade children were selected by the assistant superintendent in charge of the elementary schools in the Logansport system. Similarly, schools containing two third-grade classes were selected by the Peru superintendent of schools. Although none of the participating schools in either system were randomly selected, they were considered to be representative of the available school populations by the administrative personnel. The group tests developed for this study were administered to these children. A subsample of these children comprising two classes in each of the two school systems were retested to obtain test-retest reliability estimates for the group tests.

Additionally, an individually administered manipulative test for length conservation (ICT) was used with two other third-grade classes at Peru. In order to provide background data for the group-tested third-grade classes, two classes each of grades one, two, four, five, and six in the Peru system were tested. The same instruments were used as in the other group testing.

In order to obtain data to examine the effects of sex of experimenter and experimenter expectancy on conservation responses, the group test utilizing COL8-2 was administered to four second-grade classes at Peru.

COL8-2 and COL8-3 Group Test Sample

The sample for group testing utilizing COL8-2 and COL8-3 consisted of 406 subjects. These subjects comprised the sample to provide data for the investigation of the two methodological variables of this study. Of these subjects, 215 were second semester second-grade students from five schools in system A and 191 were first semester third-grade students from five schools in system B. The mean age of the second-grade subjects at the time the tests were administered was 8.3 years and the corresponding mean age of the third-grade subjects was 8.9 years. The 215 second-grade subjects consisted of 112 females and 103 males. The 191 third-grade subjects consisted of 95 females and 96 males.

In both systems, schools were randomly assigned to planar orientation sequence. The two classes in each school

were divided in half by use of random number sequences, then halves of classes were interchanged to form test groups. These test groups were randomly assigned to the two- or three-rod treatments.

In each system, it was necessary to use two schools to form one of the pairs of test groups due to the lack of schools having two classes at grade level. In these cases, a pair of schools was treated as a unit and this unit was randomly assigned to a planar orientation sequence. Classes were divided in half by use of random number sequences, then halves were randomly assigned to the two- or three-rod treatment for testing. Corresponding halves of the two classes formed the test groups. In each system, the last two test groups formed the sample for a test-retest reliability estimate. These sample sizes were 49 in system A and 49 in system B.

The group tests were administered to the system A subjects at three week intervals over a two month period in March and April of 1971. For the subjects in system B, the group tests were administered during a one week period in October, 1971. Retesting for test-retest reliability estimates was conducted in each school system on the fifth day following the initial test administration.

The sample for group testing to examine the effects of sex of experimenter and experimenter expectancy consisted of 91 second grade subjects from two schools in system B.

The mean age of these subjects at the time of test administration was 8.1 years. This sample consisted of 42 females and 49 males. Only the COL8-2 apparatus was utilized in testing this sample. Tests were administered to the entire sample during one day in mid-February, 1972. Test groups were formed as in the other group testing.

ICT Sample

The sample for the individually administered concrete materials test (ICT) consisted of 54 subjects from two schools in system B whose mean age at the time of testing was 8.9 years. Of the 54 subjects 31 were female and 23 were male. Two tests were individually administered to each subject. These pairs of tests were COL8-2, ICT; COL8-3, ICT; ICT, COL8-2; ICT, COL8-3. Subjects were selected from class lists alphabetized by surname. Every fourth subject was given identical test pairs from the four pairs of the sequence. The testing of this sample was completed during four consecutive school days in early November, 1971.

Across Grade Profile Sample

Two classes each of grades one, two, four, five, and six were group tested with COL8-2 and COL8-3 in order to obtain a profile of conservation scores in system B. These classes were all in one school. There were 50 first-graders, 53 second-graders, 47 fourth-graders, 44 fifth-graders, and 56 sixth-graders who were tested. The instruments were

administered to the classes as intact groups using the same planar orientation sequence as was used with the ICT sample. These subjects received the group tests during a two day period in early November, 1971.

Curriculum

All of the second-grade classes in system A used the Eicholz and Martin (1963) text. This text was designed primarily to study the system of whole numbers. Primary emphasis is placed on the structure of the system of whole numbers and understanding interrelationships between sets and numbers. Student activity is stressed by the authors.

Only four pages of the text are devoted to linear measurement, and though the teacher's edition suggests the use of names for units of measure, no mention is made of the length conservation concept. The primary emphasis on the linear measurement lessons appears to be activity focusing on the provision of experiences in working with linear measure. Since the lessons on linear measurement appear so late in the text (pages 307-310 of a 312 page text), it is questionable whether all classes received these lessons. These lessons had not been taught prior to testing. However, similar lessons on linear measurement were included at the same relative position in the first-grade text.

In system B all third-grade classes used the mathematics text authored by Keedy et al. (1970). Chapter Five of the text was devoted to a study of linear measure and

line segments. This unit consisted of approximately twenty-five pages of text. Additional lessons treating linear measurement were placed in Chapter Eleven of the text. The authors stressed discrimination between line segments and other geometric figures as well as the interrelationship of segments to geometric figures having egments as sides or edges. Active involvement of students was stressed by means of inquiry and discovery techniques. Although it was implied that the choice of unit of measure is arbitrary, no reference was made in the teacher's edition to the length conservation concept. The latter appeared to have been assumed by the authors when the textual materials were written. The third-grade subjects had not studied these materials prior to being tested by the investigator. However, the second-grade text, by the same authors, did introduce length and some linear measurement in four lessons. Other lessons in the second-grade material made use of the number line with equal units marked on the line. Consequently, units of length measure were implied as was conservation of length even though the latter was not mentioned in the teacher's edition.

Both second- and third-grade subjects had previously been exposed to length concepts, units of measure, and activities involving linear measure prior to testing, but in no case was the length conservation concept referred to in teacher's editions of the texts used by the subjects for this study.

Instruments

The Group Tests

Apparatus. Apparatus for the group tests consisted of six pieces of equipment which were constructed by the investigator; a poster board to instruct subjects on how to mark response booklets, COL8-2, COL8-3, a poster board containing the response breaker item, and two tripods on which COL8-2 and COL8-3 could be placed.

The instructional poster board was 18 inches wide and 28 inches long, having approximately the same ratio of width to length as the pages of the response booklet. Proportionately sized drawings of a "box" and a "star" were made on the poster board which corresponded to those on the pages of the response booklet.

COL8-2 and COL8-3 consisted of octagonal plywood sheets made of three-eighths inch plywood. These instruments had 32 inch widths across opposite pairs of sides. Both plywood sheets were painted flat white to avoid glare from room lighting and to provide contrast for the attached rods. In the center of COL8-2 were mounted two brown rods. The rods were 16 inches long, 1-1/4 inches wide, and 7/8 inches thick. These rods were spring-loaded to maintain position on the board and could be subjected to parallel displacement since they were mounted in parallel slots cut in the plywood. COL8-3 was similar except that midway between the

two movable rods a nonmovable rod was mounted. On both COL8-2 and COL8-3, the pairs of movable rods could only be moved in opposite directions and no part of the slot was visible during or after any transformation.

The poster board on which the response breaker materials were mounted was 22 inches wide and 28 inches long. Three-quarter-inch square rods of lengths 10 and 14 inches were mounted in the center of the board. Only the shorter rod could be moved.

Tripods were used to display the instruments during presentation to the subjects. These were constructed of white pine and were 52 inches high. Each tripod contained a slotted tray in which COL8-2, COL8-3 or the response breaker poster board would fit. In working position, the bottom of the tray, and thus the bottom of COL8-2, COL8-3, or the poster board, was 21 inches above floor level. This made the level of the rods approximately 34 inches above floor level.

Construction and Characteristics. A review of available conservation tests for group administration revealed that none of them was suitable for this study since none of them isolated the methodological variables to be investigated. Thus the researcher developed group tests to be used in conjunction with the apparatus COL8-2 or COL8-3 for this study. Both tests were based on the Piagetian oriented

film conservation test designed and developed by Wheatley (1971).

The group test used with COL8-2 consisted of nine items, four of which dealt with conservation of length. The remaining items consisted of two practice items, two pretest items, and an item to break response set. The group test used with COL8-3 consisted of the same items as did the COL8-2 test except that for each of the conservation of length items an additional response was required due to the use of three rods on COL8-3 instead of two rods as used on COL8-2. The rods for each conservation of length item could be oriented at an inclination of 0°, 45°, 90°, or 135° on both COL8-2 and COL8-3.

The Kuder-Richardson Formula 20 was used to obtain estimates of the internal reliability for each of the group tests. Additionally, since the static rod to be used as a standard of comparison was a necessary requirement for the construction of COL8-3, internal reliability estimates were computed for the conservation of length subtest which utilized only the two movable rods. These estimates are tabulated in Table 1.

Table 1.

Group Test Internal Reliability Estimates

Grade Level	KR - 20's		
	COL8-2	COL8-3	
		Total test	Subtest
2	.960	.933	.874
3	.942	.965	.941
2 and 3	.951	.949	.907

The discriminations of the test items were estimated using correlations between items and total test. The ranges of these correlations are shown in Table 2.

Table 2.

Range of Item Correlations for Grades Two and Three

Grade Level	Range of Correlations		
	COL8-2	COL8-3	
		Total Test	Subtest
2	.900 to .989	.198* to .912	.751 to .911
3	.830 to .979	.604 to .962	.793 to .980

*One correlation was .198. The remaining correlations were .626 or higher.

A complete listing of the item to total test correlations is shown in Appendix B.

Administration of the Group Tests. The group tests utilized to investigate the methodological variables of this study were administered to the subjects in system A in March, April and early May of 1971 and in system B during late October, 1971. All of these group tests were administered by the investigator. The group test used to investigate the effects of sex of test administrator and experimenter expectancy were administered by the investigator and two trained adult females. These two examiners were trained by the investigator to administer the group test utilizing the COL8-2 apparatus. Testing of the four classes involved in this phase took place in mid-February of 1972. The administration time for each testing group was approximately twenty-five minutes. In as much as it was possible to do so, groups were tested in the presence of a classroom teacher. The student desks (or tables) were arranged in a wedge configuration with the apparatus located at the apex. This configuration was chosen as a means of trying to minimize differences in the visual perception of the subjects which might result from the seating arrangement. Once a testing group had been seated, the investigator was introduced (or introduced himself). Then the investigator stated: "I am trying to make a new game for boys and girls like you. I need you to help decide what the answers to the game should be. Would you help me?" When the group agreed to help, student volunteers distributed the response

booklets and pencils supplied by the investigator. While this was being done, the investigator taped the practice poster board to the chalkboard. When the two practice items were completed, the poster board was removed. This was done to avoid copying of incorrect sequences of responses in the response booklet. Next, the two pretest items on length were administered, followed by two conservation of length items, a response breaker item, and two more conservation of length items. The conservation of length items were administered by utilizing the COL8-2 or COL8-3 apparatus. When the planar orientation of rods was changed, the investigator stood between the apparatus and subjects since this rotation was not the transformation being emphasized in this study. Transformations of rods were always carried out in such a manner that the ends of the rods remained visible to the subjects. In each case the rod to be moved was grasped at its midpoint with the test administrator's arm bent such that both ends of the rod remained visible to the subjects. Then the rod was given a translation which kept it parallel to the fixed rod on the apparatus being used. Of the two-part instructions for each item, one used the phrase "same length" and one used the phrase "is longer than". The order of the two parts was systematically changed within task presentation and between task presentation in order to provide a control for recency responses by the subjects.

The response booklets consisted of seven sheets of paper and a cover sheet. These sheets were five and one-half inches wide and eight and one-half inches long. Pages 1, 2, and 5 were identical for both COL8-2 and COL8-3. All pages in the COL8-2 booklets consisted of two parts with a drawing of a box and a star on each part.

Pages 3, 4, 6, and 7 in the COL8-3 booklets consisted of three parts with a drawing of a box and a star on each part. The pages of both types of booklet were color coded. This was done as a means of coding the planar orientation sequence of the length conservation items, to provide added interest on the part of the subjects, and to avoid the problem of possible lack of subject knowledge regarding numerals. A more complete and detailed description of the apparatus, response booklets and associated verbal instructions for test items is found in Appendix A.

Subjects were shown how to mark their responses utilizing two practice items. The subjects responded to each test item by drawing a ring around a box or a star. The test items were presented to the subjects by use of the poster boards and the COL8-2 or COL8-3 apparatus.

Description of Test Items. Items 1 and 2 were designed to acquaint the subjects with the general type of tasks in the test and provided a means of instructing the subjects on how to mark their responses in the response booklets. For item 1, the subjects were shown two books of identical size

(but different color). Then the investigator stated: "Here are two books. If you think these books are the same size, draw a ring around the box. If you think one book is bigger draw a ring around the star". PAUSE. The investigator then superimposed the books and stated: "These books are the same size, see how they fit. You should have marked the box like this (investigator placing a cut-out oval around the box at the top of the poster board). If you did not mark the box, do it now". Item 2 was administered in a similar fashion except that two books of different size were used and the order of instructions was reversed.

The pretest items, 3 and 4 were designed to measure the subjects' understanding of the relations "longer than" and "same length as" respectively. For Item 3 a 16 inch and a 20 inch rod were used. The rods used in Item 4 were both of length 16 inches. These rods were like those used in COL8-2 and COL8-3 in all respects except possibly length.

Items 5, 6, 8, and 9 were designed to measure conservation of length. These items were based on a classic Piagetian length conservation task. The rods used were natural brown wood. On COL8-2, one of two rods was moved parallel to the unmoved rod and the items measured whether the subject maintained the equality of length over the transformation. Nonconservers might focus on a pair of corresponding ends of the rods leading them to believe that since one rod projected past the other one rod was longer

(or shorter) than the other. These subjects are not capable of the composition of empty sites as described by Piaget et al. (1960). Some subjects may be led to believe that the movement stretches one rod thus making it longer (or the unmoved one shorter). The measures of conservation of length yielded by Items 5, 6, 8, and 9 provided data for four different planar orientations of rods.

Each item was scored either correct or incorrect with no partial credit being given. Each item on conservation of length (Items 5, 6, 8, and 9) was worth one point.

The Individual Concrete Test

Apparatus. The apparatus for the ICT consisted of nine-sixteenths inch by nine-sixteenths inch square rods made of natural brown wood. There were three rods each seven and one-half inches long, one rod six inches long, one rod five inches long, and five rods each one and one-half inches long. The apparatus also included a table top on which the rods were placed before the subjects.

Construction and Characteristics. The ICT was developed since it was desired to compare the group tests utilizing COL8-2 and COL8-3 with the classical length conservation tests utilizing individual administration. The ICT consisted of five items; three on conservation of length, and two on conservation of difference of length. For purposes of comparison between the ICT and group tests just two items were appropriate for consideration, namely the

items in which the placement of rods was at a horizontal or vertical inclination. Since the validity and reliability of such classical conservation tasks has been sufficiently documented by previous researchers, it was concluded that such work need not be carried out for this study.

Administration of the ICT. The ICT was administered to one class in each of two schools in system B during a four day period in early November 1971. As noted in the description of the ICT sample, each subject received the ICT and either COL8-2 or COL8-3. The administration time was approximately fifteen minutes per subject. Prior to commencing the testing the investigator told the subject about the test using the same format as in the group testing. Additionally, each subject was told that the game consisted of two parts; one part in which the subject would record his answers in the booklet provided (COL8-2 or COL8-3), and one part in which the investigator would record the subject's answers (ICT). For the ICT, a five and one-half by eight and one-half inch sheet of paper was used which was attached to the subject's booklet after he had left the testing room.

For each of the five items of the ICT, appropriate rods were placed before the subject. For each of the three conservation of length items, if the subject did not admit to the initial equality of rod length, he was encouraged to manipulate the rods to convince himself that the rods were the same length. When this was done, one rod was moved

lengthwise as in COL8-2 and COL8-3 and the subject was asked if the rods were the same length or if one rod was longer. The subject was also asked why the rods were the same length (or why one rod was longer) following the transformation. As in the group tests, questions involving the relations "same length as" or "longer than" were systematically alternated to provide contrast with the correct response in order to provide some control for recency responses. The two items on conservation of difference of length were alternated with the conservation of length items.

The individual administration of the tests utilizing COL8-2 or COL8-3 was identical to the group administration.

Description of Test Items. Items 1 and 3 were classical length conservation tasks designed to measure length conservation ability when respective rod inclinations to the horizontal were 0° and 90°. Items 2 and 4 were conservation of difference of length tasks which were designed to break possible response sets of the subjects. It was expected that most subjects would give correct responses to these items since previous research has shown that such items are easier than items on conservation of length. Item 5 consisted of one continuous rod and one rod decomposable into five smaller rods. This type of item is considerably more difficult than items using two continuous rods. The difficulty lies in part in the influence on perception of a zig-zag pattern which can be formed by the five smaller rods

and resulting apparent difference in total length. It was expected that only operational conservers would give a correct response to this item since only at this stage of development are the cognitive structures present which can override such strong perceptual influence.

CHAPTER IV

RESULTS

As stated in Chapter I, the primary purposes of this study were to investigate the effects of perceptual focus and planar orientation sequence on length conservation responses. The selected levels of the two variables defined a four-by-two factorial experimental design. Two hundred fifteen second-grade children and 191 third-grade children were subjects for this phase of the study. An additional sample of 54 second-grade subjects were used to determine the relationship of the group tests to a classical test of length conservation. A complete description of the subject population sample is found in Chapter III.

After the data had been collected, they were analyzed and the hypotheses stated in Chapter III were tested. Results of this statistical analysis and hypothesis testing are reported in the present chapter.

Conditions of Experimentation

Internal reliability estimates for the group tests were reported in Chapter III. Test-retest reliability estimates were also computed. These were calculated for two test groups from each of grade two and grade three subjects. The

computations were effected by use of the TRECOR computer program [Dixon (1970)]. Results are listed in Table 3.

Table 3.

Test-retest Correlations

Test Group	Correlation	n
GA 221	.778	23
GA 233	.573	25
GB 323	.730	26
GB 333	.572	24

Combining of Grade Two and Grade Three Data

The sample for the study, as described in Chapter III, consisted of second- and third-grade subjects. Since the mean ages of these two subsamples differed by 0.6 years, the combining of data required justification. In view of the fact that test groups of one grade level did not have consistently superior performance relative to corresponding test groups of the other grade level, it was considered admissible to combine data provided that (1) the combined data possessed homogeneity of variance and (2) mean scores between grade levels under the same test conditions were not statistically different at the .05 α-level.

To test for homogeneity of variance of the combined data, Bartlett's Test ([Winer (1962, p. 95)] was used on a

three-way classification of variables. This classification was comprised of planar orientation sequences, COL8-2 and COL8-3 instruments, and sex of subjects. The DATASUM computer program [Dixon (1970)] was used to perform the analysis. Prior to the analysis an α-level of .05 was selected. The statistical hypotheses examined were

$$H_0: \sigma^2_{111} = \sigma^2_{112} = \sigma^2_{121} = \cdots = \sigma^2_{421} = \sigma^2_{422}$$

$$H_1: \text{not all } \sigma^2_{ijk} \text{ are equal}$$

where $i = 1,2,3,4$, $j = 1,2$, $k = 1,2$, and σ^2_{ijk} is the population variance for group ijk. Bartlett's Test uses a χ^2 statistic. The critical value of the statistic for this sample and classification is $\chi^2_{.95}(15) = 25.00$. Under H_0, the analysis revealed that $\chi^2_{obs} = 5.15$ for this sample. Since $\chi^2_{obs} < \chi^2_{.95}(15)$, H_0 was not rejected. Thus there is no reason to suspect unequal variances on the basis of this test.

A t-test [Winer (1962, p. 28)] was used to investigate possible differences in mean scores between second- and third-grade subjects when COL8-2 or COL8-3 was utilized to administer the group tests. For the cases where the instrument COL8-2 was used, the following statistical hypotheses were examined:

$$H_0: \mu_{22} = \mu_{32}$$

$$H_1: \mu_{22} \neq \mu_{32}$$

where μ_{22} is the population mean for second-grade subjects under COL8-2 and μ_{32} is the population mean for third-grade subjects under COL8-3. An α-level of .05 was selected prior to the analysis. For the analysis, the TTEST computer program [Dixon (1970)] was used. The critical values for the t-statistic are $t_{.025}(203) = -1.97$ and $t_{.975}(202) = 1.97$. Under H_0, the analysis revealed that $t_{obs} = 1.56$ for this sample. Since $t_{.025}(203) < t_{obs} < t_{.975}(203)$, H_0 was not rejected at the .05 α-level. Thus, based on this test, there is no reason to suspect statistically significant differences in the performance of second- and third-grade subjects under test administration with COL8-2.

For the cases where COL8-3 was used, the following statistical hypotheses were examined:

$$H_0: \mu_{23} = \mu_{33}$$

$$H_1: \mu_{23} \neq \mu_{33}$$

where μ_{23} is the population mean for second-grade subjects under COL8-3 and μ_{33} is the population mean for third-grade subjects under COL8-3. An α-level of .05 was

selected prior to the analysis. The analysis was accomplished by use of the TTEST computer program [Dixon (1970)]. Critical values for the t-statistic for this sample are $t_{.025}(199) = -1.97$ and $t_{.975}(199) = 1.97$. Under H_0, analysis revealed that $t_{obs} = .87$. Since $t_{.025}(199) < t_{obs} < t_{.975}(199)$, H_0 was not rejected. Thus, based on this test, there is no reason to suspect statistically significant differences in performance between second- and third-grade subjects under test administration with COL8-3.

Since the statistical tests revealed no basis to suspect unequal variances or significant differences in performance between second- and third-grade subjects, the combining of data over the two grade levels was judged appropriate.

Testing of the Hypotheses

Hypothesis I(a): There are no significant differences in numbers of conserving responses measured by COL8-2 and COL8-3.

The statistical hypotheses examined were

$$H_0: \mu_3 = \mu_2$$

$$H_1: \mu_3 \neq \mu_2$$

where μ_3 is the population mean for COL8-3 and μ_2 is the population mean for COL8-2. The hypotheses were examined using a three-way classification analysis of

variance. The AVAR23 computer program was used [Veldman (1967)]. An α-level of .05 was selected prior to the analysis. Results of the analysis are listed in Table 4.

Table 4.

Analysis of Variance: 4x2x2 ANOV of Sequence, Apparatus, and Sex of Subject

Source	MS	df	F	P
A	12.464	3	4.0664	.0075
B	25.221	1	8.2282	.0046
C	1.635	1	.5335	.5275
AB	4.213	3	1.3745	.2489
AC	7.459	3	2.4335	.0633
BC	7.448	1	2.4300	.1157
ABC	1.286	3	.4197	.7428
Between	7.372	15		
Within	3.065	390		
Total	3.225	405		

In Table 4, factor

A = sequence of planar orientations (four levels),

B = apparatus used (two levels), and

C = sex of subjects (two levels).

Since the observed F-ratio for the B main effects was significant ($p<.05$), H_0 was rejected at the .05 α-level.

The means for factor B main effects are listed in Table 5.

Table 5.

Means for Apparatus Levels From Three-way ANOV

Apparatus	Means
COL8-2	1.4399
COL8-3	1.9480

Results of the analysis of variance listed in Table 4 also revealed significance of overall main effects for sequences of orientation. Means for factor A main effects are listed in Table 6.

Table 6.

Means for Sequence Levels From Three-way ANOV

Sequence	Means
1	1.7857
2	1.7484
3	1.1961
4	2.0455

The effects of sequence are treated in more detail by an examination of Hypothesis II.

The results listed in Table 4 revealed no significant differences in responses of male and female subjects at the

.05 α-level and no significant interactions among the three factors analyzed.

Cell characteristics for the analysis of variance results in Table 4 are listed in Table 7.

Table 7.

Cell Characteristics for the Three-way ANOV

Cell	n	M	s
A1B1C1	26	1.3462	1.8961
A1B1C2	28	1.2857	1.8024
A1B2C1	29	1.9655	1.6793
A1B2C2	22	2.5455	1.9695
A2B1C1	27	1.4815	1.6955
A2B1C2	19	1.4211	1.8048
A2B2C1	22	1.5909	1.8168
A2B2C2	26	2.5000	1.6553
A3B1C1	35	1.7429	1.8043
A3B1C2	24	.7083	1.5174
A3B2C1	21	1.3333	1.7701
A3B2C2	33	1.0000	1.4790
A4B1C1	16	2.0000	2.0656
A4B1C2	30	1.5333	1.8144
A4B2C1	23	2.6087	1.6164
A4B2C2	25	2.0400	1.7436

Hypothesis I(b): There are no significant differences in the number of conservers at the 100 percent criterion level as measured by COL8-2 and COL8-3.

The statistical hypotheses examined were

$$H_0: f_2 = f_3$$

$$H_1: f_2 \neq f_3$$

where f_2 is the population frequency under COL8-2 and f_3 is the population frequency under COL8-3. The hypotheses were examined by use of a contingency table for frequency comparison [McNemar (1969, Ch. 13)] which uses a chi square statistic. Such an analysis was undertaken because a criterion level of conservation was used in the formulation of Hypothesis I(b) and this information was more readily available from data sheets than data cards which would have required a card sort or an amended computer program for processing. Since observed frequencies were to be compared by dichotomizing the data along two dimensions, the chi square statistic was deemed appropriate [McNemar (1969, p. 255)]. Use of the chi square statistic in subsequent analyses of observed frequencies is based on the explanation just given. An α-level of .05 was selected prior to performing the analysis. Observed frequencies for the 100 percent criterion are listed in Table 8.

Table 8.

Contingency Table for Observed Frequency Comparison: 100 Percent Criterion

Instrument	Subject Classification	
	Conserver	Nonconserver
COL8-2	60	145
COL8-3	71	130

The smallest expected cell frequency was $E_{min} = 64.85$. Thus no correction for discontinuity was required. The critical value of the chi square statistic for the sample was $\chi^2_{.95}(1) = 3.84$. Under H_0, $\chi^2_{obs} = 1.70$. Since $\chi^2_{.95}(1) > \chi^2_{obs}$, H_0 was not rejected at the .05 α-level.

Since Piaget et al. (1960) use the 75 percent level to denote operational conservation, Hypothesis I(b) and statistical hypotheses H_0 and H_1 were also tested using a 75 percent performance criterion at the pre-selected .05 α-level. A contingency table analysis for frequency comparison was used for this test [McNemar (1970), Ch. 13)]. Observed frequencies for the 75 percent criterion are in Table 9.

Table 9.

Contingency Table for Observed Frequency Comparison: 75 Percent Criterion

Instrument	Subject Classification	
	Conserver	Nonconserver
COL8-2	67	138
COL8-3	86	115

The smallest expected cell frequency was $E_{min} = 75.75$. No correction for continuity was required. The critical value of the chi square statistic for the sample was $\chi^2_{.95}(1) = 3.84$. Under H_0, $\chi^2_{obs} = 4.41$. Since $\chi^2_{obs} > \chi^2_{.95}(1)$, H_0 was rejected at the .05 α-level.

Hypothesis II(a): The sequencing of planar orientations has no significant effect on conservation of length responses as measured by COL8-2.

The statistical hypotheses examined were

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$$H_1: \mu_i \neq \mu_j \text{ for some } i \text{ and } j, \ i \neq j$$

where μ_1, μ_2, μ_3 and μ_4 are the population means under sequences 1, 2, 3, and 4 respectively. The hypotheses were examined by use of the BMD01V computer program [Dixon (1970)] with a pre-selected α-level of .05. Results of the analysis are listed in Table 10.

Table 10.

Analysis of Variance: Sequence Effects Within COL8-2

Source	MS	df	F
Between Sequences	1.5598	3	.4811
Within Sequences	3.2422	201	
Total		204	

The critical value of the F-statistic for this test was $F_{.95}(3,201) = 2.65$. Under H_0, $F_{obs} = .48$. Since $F_{obs} < F_{.95}(3,201)$, H_0 was not rejected at the .05 α-level. Thus, the overall sequence effect revealed by the data of Table 4, cannot be attributed to the use of the COL8-2 apparatus.

> Hypothesis II(b): The sequencing of planar orientations has no significant effect on conservation of length responses as measured by COL8-3.

The statistical hypotheses examined were

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$$H_1: \mu_i \neq \mu_j \text{ for some } i \text{ and } j, i \neq j$$

where μ_1, μ_2, μ_3, and μ_4 are the population means under sequences 1, 2, 3, and 4 respectively. The hypotheses were examined by use of the MBD01V computer program

[Dixon (1970)] with a pre-selected .05 α-level. Results of the analysis are in Table 11.

Table 11.

Analysis of Variance: Sequence Effects Within COL8-3

Source	MS	df	F
Between Sequences	15.6210	3	5.2994
Within Sequences	2.9477	197	
Total		200	

The critical value of the F-statistic for this test was $F_{.95}(3,197) = 2.65$. Under H_0, $F_{obs} = 5.30$. Since $F_{obs} > F_{.95}(3,197)$, H_0 was rejected at the .05 α-level. Since H_0 was rejected it appears, in view of Hypothesis II(a), that the significant overall sequence effect noted in Table 4 can be attributed to the use of the COL8-3 apparatus.

A Neuman-Keuls Sequential Range Test [Winer (1962, p. 80)] was then performed on the ranked means μ_i, $i = 1, 2, 3, 4$. This test was performed by use of the NKTEST computer program [Dixon (1970)]. Results of this test are in Table 12.

Table 12.

Neuman-Keuls Sequential Range Test:
Significance of Sequence Effects
Within COL8-3

Rank	4	3	2
1	1.183**	.229	.097
2	1.086**	.132	
3	.954**		

** - significant at .01 α-level

In terms of the original sequences, the test revealed an ordering $4 \geq 1 \geq 2 > 3$ where only the strict inequality represents a significant difference.

> Hypothesis III(a): There are no significant effects on conservation responses which are due to practice when multiple items of a similar nature are presented to subjects by means of COL8-2.
>
> Hypothesis III(b): There are no significant effects on conservation responses which are due to practice when multiple items of a similar nature are presented to subjects by means of COL8-3.

Prior to testing Hypotheses III(a) and III(b), it was deemed advisable to construct a standard against which judgments about the statistical hypotheses could be made. Consequently, a practice effect was defined which was referenced to the administration of multiple items of a similar nature.

Definition: A practice effect is said to be evidenced if scores on a sequence of rod orientations form a non-decreasing sequence with a significant difference between at least one pair of scores.

The data used for the examination of practice effects are listed in Tables 13 and 14.

Table 13.

Practice Effects: Conserving Responses for Combined Data Under COL8-2

Sequence	Number of Conserving Responses				n
	Item One	Item Two	Item Three	Item Four	
1	16	17	18	20	54
2	12	13	21	21	46
3	16	20	20	22	59
4	20	20	20	18	46

Table 14.

Practice Effects: Conserving Responses for Combined Data Under COL8-3

Sequence	Number of Conserving Responses				n
	Item One	Item Two	Item Three	Item Four	
1	30	27	29	27	51
2	24	23	26	27	48
3	14	15	17	15	54
4	27	25	27	30	48

Table 14 reveals no evident practice effects when the definition is applied to the data.

Table 13 reveals the possibility of practice effects in sequences 1, 2, and 3 under COL8-2. For these sequences the following statistical hypotheses were examined:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$$H_1: \mu_i \neq \mu_j \text{ for some } i \text{ and } j, \; i \neq j$$

where μ_1, μ_2, μ_3, and μ_4 are population means for corresponding item number within the particular sequence. The hypotheses were examined by use of the ANOVAR computer program [Veldman (1967)]. An α-level of .05 was selected prior to the analysis. Results of the analysis of variance are listed in Table 15 for sequence one, Table 16 for sequence two, and Table 17 for sequence three.

Table 15.

Analysis of Variance: Practice Effects Within Sequence One

Source	MS	df	F	p
Between Items	.0309	3	1.256	.2907
Between Subjects	.8173	53		
Error	.0246	159		
Total	.2201	215		

Table 16.

Analysis of Variance: Practice Effects Within Sequence Two

Source	MS	df	F	p
Between Items	.5272	3	9.281	.0001
Between Subjects	.7412	45		
Error	.0568	135		
Total	.2328	183		

Table 17.

Analysis of Variance: Practice Effects Within Sequence Three

Source	MS	df	F	p
Between Items	.1073	3	2.602	.0526
Between Subjects	.7710	58		
Error	.0413	174		
Total	.2222	235		

Application of the definition of practice effect to the results of the analysis revealed a significant effect only for sequence two. Hence, a Neuman-Keuls Sequential Range Test was performed on the item means for that sequence. The test was accomplished by use of the NKTEST computer program [Dixon (1970)]. Results of the Neuman-Keuls test are in Table 18.

Table 18.

Neuman-Keuls Sequential Range Test:
Practice Effects Within Sequence Two

Rank	4	3	2
1	.196**	.174**	.000
2	.196**	.174**	
3	.022		

** - significant at .01 α-level

By this test, the means of sequence items 3 and 4 are both significantly larger than those of both sequence items 1 and 2 at the .01 α-level.

> Hypothesis IV(a): There are no significant differences in length conservation reponses between male and female subjects as measured by COL8-2.

The statistical hypotheses examined were

$$H_0: \mu_{M2} = \mu_{F2}$$

$$H_1: \mu_{M2} \neq \mu_{F2}$$

where μ_{M2} is the population mean for male subjects under COL8-2 and μ_{F2} is the population mean for female subjects under COL8-2. These hypotheses were examined by use of the BMD01V computer program [Dixon (1970)]. An α-level of .05 was selected prior to the analysis. Results of the analysis are listed in Table 19.

Table 19.

Analysis of Variance: Male and Female Performance Under COL8-2

Source	MS	df	F
Between Groups	1.6344	1	.5067
Within Groups	3.3255	203	
Total		204	

The critical value of the F-statistic for this test is $F_{.95}(1,203) = 3.89$. Under H_0, $F_{obs} = .51$. Since $F_{obs} < F_{.95}(1,203)$, H_0 was not rejected at the .05 α-level.

Hypothesis IV(b): There are no significant differences in length conservation responses between male and female subjects as measured by COL8-3.

The statistical hypotheses examined were

$$H_0: \mu_{M3} = \mu_{F3}$$

$$H_1: \mu_{M3} \neq \mu_{F3}$$

where μ_{M3} is the population mean for male subjects under COL8-3 and μ_{F3} is the population mean for female subjects under COL8-3. The hypotheses were examined by use of the BMD01V computer program [Dixon (1970)] with a pre-selected .05 α-level. Results of the analysis are in Table 20.

Table 20.

Analysis of Variance: Male and Female Performance Under COL8-3

Source	MS	df	F
Between Groups	.1755	1	.0057
Within Groups	3.1527	199	
Total		200	

The critical value of the F-statistic for this test was $F_{.95}(1,199) = 3.89$. Under H_0, $F_{obs} = .006$. Since $F_{obs} < F_{.95}(1,199)$, H_0 was not rejected at the .05 α-level.

> Hypothesis V: There are no significant differences in the numbers of second-grade operational conservers of length when COL8-2 is administered by male and female examiners.

The statistical hypotheses examined were

$$H_0: \quad f_M = f_F$$

$$H_1: \quad f_M \neq f_F$$

where f_M is the population frequency under male administration and f_F is the population frequency under female administration. The hypotheses were examined by use of a contingency table for frequency comparison [McNemar (1969,

Ch. 13)] with a pre-selected α-level of .05. The observed frequencies are listed in Table 21.

Table 21.

Contingency Table for Observed Frequency Comparison: Sex of Examiner

Sex of Examiner	Subject Classification	
	Conserver	Nonconserver
Male	7	18
Female	15	11

The smallest expected cell frequency was $E_{min} = 10.78$. Thus no correction for discontinuity was required. The critical value of the chi square statistic was $\chi^2_{.95}(1) = 3.84$. Under H_0, $\chi^2_{obs} = 4.58$, and since $\chi^2_{obs} > \chi^2_{.95}(1)$, H_0 was rejected at the .05 α-level.

Hypothesis VI: The expectancy of the test administrator has no significant effect on the number of second-grade operational conservers of length as measured by COL8-2.

The statistical hypotheses examined were

$$H_0: \quad f_H = f_L$$

$$H_1: \quad f_H \neq f_L$$

where f_H is the population frequency under high expectation and f_L is the population frequency under low expectation. The hypotheses were examined by use of a contingency table for frequency comparison [McNemar (1969), Ch. 13)] with a pre-selected α-level of .05. The observed frequencies are in Table 22.

Table 22.

Contingency Table for Observed Frequency Comparison: Expectancy of Examiner

Expectancy of Examiner	Subject Classification	
	Conserver	Nonconserver
High	12	8
Low	14	6

Since the smallest expected cell frequency $E_{min} = 7.50$, the Yates correction for discontinuity was included in the computation of χ^2_{obs}. The critical value of the chi square statistic was $\chi^2_{.95}(1) = 3.84$. Under H_0, $\chi^2_{obs} = .11$. Since $\chi^2_{obs} < \chi^2_{.95}(1)$, H_0 was not rejected at the .05 α-level.

Hypothesis VII(a): There is no significant correlation between responses on the group conservation of length test COL8-2 and the ICT.

Subtests consisting of two items on length conservation were identical on the COL8-2 and ICT apparatus.

Product-moment correlation coefficients were calculated for these subtests. ICT scores were based on classical Piagetian assessment procedures which included evaluation of subject response justification. The computed correlations are listed in Table 23.

Table 23.

Correlation Between COL8-2 and ICT Subtests

Order of Administration	Product-moment Correlation	n
COL8-2, ICT	.93	14
ICT, COL8-2	1.00	13

In order to determine if $r = .93$ was significantly different from zero, the following statistical hypotheses were examined:

$$H_0: \rho = 0$$

$$H_1: \rho \neq 0$$

where ρ is the population correlation coefficient between the subtests. Under H_0, the t-statistic is

$$t_{obs} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

where r is the observed correlation and n is the number of observations [Ostle (1963, p. 225)]. The critical values for the t-statistic for this sample were $t_{\alpha/2}(n-2)$ and $t_{1-\alpha/2}(n-2)$. For the present subsample, $n = 14$. A preselected α-level of .05 was used. Hence the critical values were $t_{.025}(12) = -2.18$ and $t_{.975}(12) = 2.18$. Under H_0, $t_{obs} = 8.76$. Since $t_{obs} \geq t_{.975}(12)$, H_0 was rejected at the .05 α-level.

> Hypothesis VII(b): There is no significant correlation between responses on the group conservation of length test COL8-3 and the ICT.

Subtests consisting of two items on conservation of length were identical on the COL8-3 and ICT apparatus only in terms of the orientations used. The items differed both in the number of rods and in the transformation used. Product-moment correlation coefficients were computed for the two subtests. As with Hypothesis VII(a), ICT scores were based on classical Piagetian procedures and subject response justification was required. The calculated correlations are listed in Table 24.

Table 24.

Correlation Between COL8-3 and ICT Subtests

Order of Administration	Product-moment Correlation	n
COL8-3, ICT	.70	14
ICT, COL8-3	.37	13

Using the same statistics and statistical hypotheses as for Hypothesis VII(a), tests were conducted to determine if the correlations were significantly different from zero using a pre-selected .05 α-level. For the subsample used, $n = 13$. The critical values for the t-statistic were $t_{\alpha/2}(n-2)$ and $t_{1-\alpha/2}(n-2)$. At the pre-selected .05 α-level, the critical values were $t_{.025}(11) = -2.20$ and $t_{.975}(11) = 2.20$. Under H_0, $t_{obs} = 7.21$. Since $t_{obs} \geq t_{.975}(11)$, H_0 was rejected at the .05 α-level.

Next, Fisher's Z Transformation was used to test for significance of the difference between the correlations .37 and .70 [Bruning and Kintz (1968, p. 191)]. The statistical hypotheses examined were

$$H_0: \ r_1 = r_2$$

$$H_1: \ r_1 \neq r_2$$

where r_1 and r_2 are the independent product-moment correlations to be compared. The transformation for changing a correlation r to a Fisher Z is

$$Z = 1/2 \left[\log_e(1+r) - \log_e(1-r)\right].$$

The critical values for the Z statistic using the preselected .05 α-level are $Z_{.025} = -1.96$ and $Z_{.975} = 1.96$. Under H_0, $Z_{obs} = 1.10$. Since $Z_{.025} < Z_{obs} < Z_{.975}$, H_0 was not rejected.

Descriptive Statistics

Proportions of conserving responses were calculated for the combined data for the group tests administered to grade two and grade three subjects. These proportions are listed in Tables 25 and 26.

Table 25.

Proportions of Conserving Responses Under COL.8-2

Sequence	Rod Orientation				Total
	0°	45°	90°	135°	
1	.296	.315	.370	.334	.329
2	.456	.261	.283	.456	.364
3	.373	.339	.271	.339	.331
4	.435	.391	.435	.435	.424

Table 26.

Proportions of Conserving Responses
Under COL8-3

Sequence	Rod Orientation				Total
	0°	45°	90°	135°	
1	.588	.530	.568	.530	.554
2	.562	.500	.480	.542	.521
3	.278	.278	.260	.315	.282
4	.520	.625	.562	.562	.568

In order to give some indication of whether the frequency of conserving responses remained stable as the number of items increased, the number of conserving responses across the number of items was tabulated. These frequencies are listed in Table 27.

Table 27.

Proportions of Subjects Conserving Across
Number of Length Conservation Items

Number of Items Conserved	Proportion of Subjects	
	COL8-2(n=205)	COL8-3(n=201)
1 or more	.434(89)	.612(123)
2 or more	.381(78)	.522(105)
3 or more	.327(67)	.428 (86)
4	.293(60)	.353 (71)

In order to obtain a profile of performance on the group tests, two classes in each of grades 1, 2, 4, 5, and 6 were tested as intact groups. This sample is described in Chapter III. Sequence 2 was used with each class and proportions of conservers calculated for each rod orientation. The results of this testing are listed in Tables 28 and 29 for COL8-2 and COL8-3 respectively.

Table 28.

Across Grade Profile: Proportions of Conserving Responses Under COL8-2

Grade	Rod Orientation				Total
	0°	45°	90°	135°	
1	.042	.042	.083	.083	.060
2	.200	.120	.160	.200	.163
3	.433	.381	.381	.443	.410
4	.625	.500	.542	.583	.563
5	.870	.740	.837	.783	.771
6	.807	.807	.807	.770	.769

Table 29.

Across Grade Profile: Proportions of Conserving Responses Under COL8-3

Grade	Rod Orientation				Total
	0°	45°	90°	135°	
1	.440	.360	.440	.240	.370
2	.185	.163	.222	.222	.194
3	.511	.543	.500	.479	.508
4	.652	.522	.566	.783	.630
5	.750	.700	.700	.700	.713
6	.863	.932	.793	.793	.845

CHAPTER V

CONCLUSIONS, IMPLICATIONS, RECOMMENDATIONS AND LIMITATIONS

As stated in Chapter I, the primary purpose of the experiment was to study the effects of perceptual focus and planar orientation of rods on conservation responses. The literature reviewed in Chapter II substantiated the need for such an investigation and suggested group testing as a feasible vehicle for data collection. Since none of the group tests available were adequate for investigation of the variables to be studied, group tests and related instrumentation were developed for the experiment. The sample selected for the study consisted of second- and third-grade subjects in school systems of two cities located in north-central Indiana. These systems were selected on the bases of willingness to cooperate in the study and school populations large enough to provide adequate sample size. After the data had been collected, they were analyzed and appropriate statistical hypotheses were tested.

Hypothesis I

(a) There are no significant differences in numbers of conserving responses measured by COL8-2 and COL8-3.

(b) There are no significant differences in the number of conservers at the 100 percent criterion level as measured by COL8-2 and COL8-3.

Conclusions and Implications

The purpose of Hypothesis I was two-fold: first, to determine if significant overall differences in numbers of responses could be detected, and secondly, to determine if existent significant differences carried through to a preset criterion level. Piaget et al. (1960) and others have shown that prior to attaining concrete operational behavior, subjects are influenced by their perceptions to varying degrees. Thus, the additional control introduced into the perceptual field by means of the apparatus COL8-3 and its use could be expected to result in response patterns which differ from those observed using more traditional instrumentation by enhancing decentration.

Analysis of the data supports this assumption. Hypothesis I(a) was rejected at the five percent level of significance. Thus, based on the present analysis it is suggested that the introduction of a third rod into the apparatus coupled with simultaneous translation of two of the three rods in opposite directions results in more conserving responses.

Hypothesis I(b) was not rejected at the five percent level of significance. This is not an unexpected finding because of criterion level chosen. If subjects conserve at

the 100 percent criterion level the associated intellectual structure can be considered complete and consequently no differences in response levels would be expected regardless of the form of instruments used in the assessment procedure. However, such an assumption would not be made at the level of operational conservation of length. In a study by Halpern (1965) it was suggested that one may expect some perceptual influence well into the stage of concrete operations. For this reason, Hypothesis I(b) was re-examined using the 75 percent criterion level. Using the operational conservation criterion, Hypothesis I(b) was rejected at the five percent level of significance. In this case there were significantly more operational conservers measured by COL8-3 than by COL8-2. Thus it is suggested that, at the level of operational conservation of length, subjects are still influenced by perception and that COL8-3 appears to facilitate the decentering process. It may be that simultaneous translation of two of three rods in opposite directions helps disengage subject focus from one aspect of the perceptual field (namely focus on states) and leads to a consideration of the transformation.

The results of data analysis for Hypothesis I suggest that the introduction of the three-rod apparatus has promise as an experimental technique. Based on analysis of the data collected in this experiment, it is suggested that the assessment of conservation of length can be improved. The

present data suggest that, particularly in group testing procedures, a significantly higher proportion of conservers of length may be identified utilizing procedures similar to those used with COL8-3 in this study.

As Elkind (1967) noted, Piaget's intent has been to measure identity conservation. Thus the assessment procedure could use just one rod. However, in such a case, no standard of comparison is present thus forcing subjects to rely on memory. In order to control for memory, a two-rod apparatus is generally used in which there is a standard of comparison. In this procedure, conservation of equivalence is examined and conservation of identity is inferred.

In the conventional assessment procedure using two rods, there appears to be no mediator which shifts subject focus to other aspects of the perceptual field. However, the use of COL8-3, with the simultaneous movement of two rods and a two-part instructional sequence, appears to provide a mediator which shifts subject focus to other relevant aspects of the perceptual field. Consequently, the use of COL8-3 appears to provide a means of obtaining a more accurate measure of length conservation ability during the late preoperational and early concrete operational periods. In light of this and the findings, the importance of the methodological variables examined in the present study is substantiated.

Hypothesis II

(a) The sequencing of planar orientations has no significant effect on conservation of length responses as measured by COL8-2.

(b) The sequencing of planar orientations has no significant effect on conservation of length responses as measured by COL8-3.

Conclusions and Implications

The purpose of Hypothesis II was to determine if the orientation sequence used with instruments COL8-2 and COL8-3 had significant effects on subject response levels. The literature reviewed in Chapter II revealed that some investigators had identified the variable [Bittner and Shinedling (1968) and Shah (1969)]. However, no one had studied planar orientation sequence as an experimental variable.

The analysis of the data for this experiment led to non-rejection of Hypothesis II(a), but Hypothesis II(b) was rejected at the five percent level of significance. It is suggested that in addition to drawing subject attention to the transformation, COL8-3 may also, because of the two-phase response procedure, provide a mediator which leads the subject to consider other aspects of the perceptual field; i.e. sequence of orientations. Such a difference in sequence effects may be a direct result of the differences in instrumentation coupled with the sets of instructions

used in the assessment procedure. One major difference in instrumentation may be the perceptual strength of the rod configurations of the two apparatuses after the transformation. The perceptual strength of the post-transformation rod configuration appeared, to the experimenter, to be considerably greater for COL8-3 than for COL8-2. Post-transformation perceptual strength can be considered from two points of view. One viewpoint suggests that if the perceptual strength of the COL8-3 configuration is greater than that of COL8-2 then the means for sequence by apparatus interaction effects should be lower for COL8-3 than for COL8-2. The reason for this could be attributed to the fact that an irrelevant cue is being accentuated. The other point of view is that the cue strength of the COL8-3 configuration is less with simultaneous rod movement and two-part instructions and thus subject focus is shifted to a consideration of other more relevant aspects of the perceptual field. In this case, one could expect the sequence by apparatus interaction means to be higher for COL8-3 than COL8-2. The calculated means for sequence by apparatus interactions are in Table 30.

Table 30.

Means for Sequence by Apparatus Interactions

Sequence	Apparatus	
	COL8-2	COL8-3
1	1.3159	2.2555
2	1.4513	2.0455
3	1.2256	1.1667
4	1.7667	2.3243

The data in Table 30 does not appear to support greater perceptual cue strength for COL8-3 relative to COL8-2 because of the fact that associated instruction sequences differed. It is suggested that the overall higher means for COL8-3 reflect the mediational effects of rod movement and two-part instructions associated with COL8-3.

A posteriori data analysis suggested that Sequence 3 was significantly poorer than the other three sequences used with COL8-3. It is suggested that an optimum sequence should be identified through further experimentation. Such experimentation might lead to a much improved instrument for conservation of length assessment by providing for maximal measures of length conservation. Additionally, in view of the test-retest correlations reported in Chapter IV (Table 3), higher test-retest correlations could be expected.

Hypothesis III

(a) There are no significant effects on conservation responses which are due to practice when multiple items of a similar nature are presented to subjects by means of COL8-2.

(b) There are no significant effects on conservation responses which are due to practice when multiple items of a similar nature are presented to subjects by means of COL8-3.

Conclusions and Implications

The literature reviewed in Chapter II revealed that a majority of experimental studies of conservation included only one or two items over a given content area. Thus the question arises regarding possible practice effects if several items are used which deal with the same content area. The purpose of examining Hypothesis III was to provide some information with respect to the question of possible practice effects over different orientations during conservation assessment. The investigator, realizing that individuals might have differences of opinion regarding what constitutes practice effects, formulated a definition for the purposes of this study. Of the eight groups of subjects who received group administered tests, only one group had scores which satisfied the definition of practice effect. On this basis it is concluded that no practice

effects can be claimed in the present study. It is suggested that inclusion of several items covering the same content area does not significantly elevate conservation scores of subjects. Similar experiments need to be conducted in the other conservation content areas.

Hypothesis IV

(a) There are no significant differences in length conservation responses between male and female subjects as measured by COL8-2.

(b) There are no significant differences in length conservation responses between male and female subjects as measured by COL8-3.

Conclusions and Implications

Previous research has, to a large extent, established that there are no significant differences in the performance of male and female subjects on tests of conservation [Goldschmid (1967), Nelson (1970) and others]. Because new methodological variables were studied in this experiment and new instrumentation was used, it was deemed advisable to check for possible performance differences which might be attributed to sex of subject. No significant differences in performance of male and female subjects were found relative to COL8-2 or COL8-3. Thus neither Hypothesis IV(a) nor IV(b) was rejected. This suggests that the use of the instruments developed for this study will not yield measures

of conservation of length which differ from a majority of previous experiments as regards sex of the subject.

Hypothesis V

There are no significant differences in the number of second-grade operational conservers of length when COL8-2 is administered by male and female examiners.

Conclusions and Implications

A few experimenters in the area of conservation have suggested the importance of the experimenter as a variable [Zimiles (1963) and Bittner and Shinedling (1968)]. In particular, Bittner and Shinedling (1968) showed that sex of experimenter is a factor which might have significant influence on conservation level. The purpose of Hypothesis V was to test the assumption that sex of experimenter has a significant effect on conserving responses. Hypothesis V was rejected at the five percent level of significance. Second-grade subjects in this phase of the experiment performed at a significantly higher level under female test administration than under test administration by a male. While the results are not conclusive, due to a lack of subjects needed for a complete experimental design, the importance of sex of examiner is heightened. Further work needs to be done with this variable.

The implications of such a variable are clear. Adjustments in testing may be required both across grade level

and content area being assessed. Not only may there be important implications for conservation assessment, but for other forms of educational assessment and staffing as well.

Historically, it has been the social custom for a mother to devote a major portion of time to her young children. The assignment of female teachers at the lower elementary grades is probably based on this cultural aspect. Thus one could reasonably expect a young child to react differently toward female and male adults and differential responses to female and male examiners would thus be expected. This suggests that the introduction of male examiners into the elementary school may require reconsideration if further experimentation at various grade levels supports the results of this phase of the study.

Hypothesis VI

The expectancy of the test administrator has no significant effect on the number of second-grade operational conservers of length as measured by COL8-2.

Conclusions and Implications

The purpose of this phase of the study was to determine if experimenter expectancy with regard to test groups would result in measurable differences in test group performance. Rosenthal (1966, Ch. 8-16) has discussed the importance of expectancy in experimentation. In the present study, the trained examiners did not know that in fact the test groups

were randomly formed from two available second-grade classes. No significant differences in group performances were detected at the pre-selected α-level. Consequently, Hypothesis VI was not rejected. Though no differences were detected in the present experiment, the investigator suggests that, in view of Rosenthal's (1966) discussion, the question is still open. In the present case, the examiners were trained in test administration by the investigator. However, the role of expectancy in the elementary classroom appears to be a much larger area than that tested in this experiment. It seems clear that more experimentation needs to be done with regard to the variable of expectancy in the area of conservation.

Hypothesis VII

(a) There is no significant correlation between responses on the group conservation of length test COL8-2 and the ICT.

(b) There is no significant correlation between responses on the group conservation of length test COL8-3 and the ICT.

Conclusions and Implications

The purpose of Hypothesis VII was to obtain a measure of validity for the tests and instruments compared to those used in classical assessment procedures. For Hypothesis VII(a), the correlations reported suggest that neither the

ICT nor COL8-2 influences the performance of subjects on the other. Further, the high correlations (.93 and 1.00) suggest that both instruments measure the same content. Hypothesis VII(a) was rejected at the five percent level of significance.

For Hypothesis VII(b) similar results were found The respective correlations of .70 for COL8-3, ICT and .37 for ICT, COL8-3 were significantly different from zero and not significantly different from each other at the five percent level of significance. This suggests that both instruments measure the same content and that when the two are sequentially administered neither appears to influence the other to a significant degree. Hypothesis VII(b) was rejected at the five percent level of significance. The ICT, COL8-3 correlation of .37 was unexpectedly small. Re-analysis of the data showed that, due to the small sample size, if one pair of scores was deleted where the shift was from conserving on the ICT to nonconserving on COL8-3 the resulting correlation coefficient was .68 instead of .37. Thus perhaps these correlations should be computed for larger samples.

Hypothesis VII suggests that the group test using instruments COL8-2 and COL8-3 possesses content validity when correlated with classical Piagetian tests of conservation of length.

Conclusions and Implications of Descriptive Data

The data of Tables 25 and 26 lend support to the results of the analysis of sequence effects reported in conjunction with Hypothesis II. There appear to be no major differences between sequences in the proportions of conserving responses under COL8-2. However, under COL8-3, the proportion of conserving responses for sequence three is considerably smaller than those for the remaining three sequences.

The data of Table 27 support the results Rothenberg (1969) found for number conservation. This finding suggests that further consideration of criteria of conservation may be needed to bring a measure of agreement regarding what constitutes conservation. It would appear that stability of response across the number of similar tasks as well as stability across number of transformations should be considered as a criterion used to help define the term conserver.

The across-grade profile data of Tables 28 and 29 revealed some variation. Generally, with each apparatus there was associated an increase in proportions of correct responses with higher grade level. COL8-2 appears to level off at grades five and six while COL8-3 still appears to discriminate at those grade levels. This may be attributed to the refinement in conservation assessment introduced by

COL8-3. Additionally, under COL8-3, grade one had a higher response level than grade two. The only available explanation for this inversion is the high degree of copying observed by the experimenter during test administration. It is noted that this particular class had a substitute teacher on the day the test was administered. This may have introduced a lack of control which contributed to the high degree of copying.

Summary of Major Results

Significantly more conserving responses were measured by COL8-3 than by COL8-2. These differences carried through to the operational level of conservation. It is suggested that simultaneous rod movement introduces a mediator which is effective in aiding decentration into the period of concrete operations. The mediator appears to be composed of a combination of the simultaneous rod translation and two-part sequence of instructions utilized in this experiment. These two aspects of the mediator appeared to shift subject focus from states to a consideration of other relevant aspects of the perceptual field. Because of this shift, it is suggested that subjects were less influenced by rod translation under COL8-3 than under COL8-2.

Sequencing of planar orientations had a significant effect on conserving responses only under COL8-3 administration. It is suggested that the planar orientation sequence

may be one aspect considered by the subject during the decentration process. Since no practice effects were revealed by the analysis, it is suggested that the first orientation of the sequence may be important. The analysis revealed that the sequence having an initial vertical orientation of rods was the poorest of the four sequences used in the study.

Sex of test administrator was revealed to be a significant factor in length conservation assessment at the second-grade level. Subjects of the present experiment responded correctly significantly more often to a female examiner than to a male examiner. This finding was not unexpected in view of previous research, social custom, and teacher assignment in schools.

Both COL8-2 and COL8-3 group tests of length conservation are significantly correlated with classical Piagetian tests of length conservation. Thus, content validity is supported for the group test developed for this study. The high internal consistency of the COL8-3 administered group test (.91) coupled with content validity support the use of the group test under COL8-3 as a viable instrument for length conservation assessment.

Recommendations for Further Research

This experiment has raised a number of questions and problems which will require further research.

(1) The sequences of planar orientations used in this study required each of the four possible orientations to begin exactly one sequence so that each of the four sets of permutations of orientations would be represented. In view of the fact that COL8-3 appears to provide an improvement in the assessment procedure compared to apparatuses used in other experiments, results of the present study should be compared to those of a similar study in which sequences are randomly selected in order to determine an optimum sequence to be used with the instrument.

(2) In the present experiment, corresponding dimensions of rods on COL8-2 and COL8-3 were identical. Conservation of length using an apparatus in which length of rods remains constant, but where various widths are used should be investigated. It is possible that there may exist a hierarchy within the various conservations.

(3) The method of effecting rod transformation in the testing procedure should be studied. Some possibilities are (a) grasping the middle of a rod with the fingers and pushing or pulling, (b) pushing a rod with some instrument, (c) moving a rod by means unseen by the child, and (d) grasping a rod by one end and pushing or pulling.

(4) Results of this study suggest that adaptations of transformations and orientation should be applied to other content areas of conservation where possible.

(5) Careful experimentation using a more complete design should be carried out across grade levels and content areas on the variable, sex of experimenter.

(6) Where taped instructions are used in the assessment procedure, the effects of both female and male taped instructions should be studied.

(7) The role of memory during conservation assessment should be carefully studied. In particular, a way should be devised to determine if subjects retain a global picture of the pre-transformation state and then base their responses on application of this memory picture to the post-transformation configuration of objects.

(8) The stability of conserving responses across the number of similar tasks requires further study. Experiments should be performed for each content area of conservation using both similar tasks and dissimilar transformations. Such studies could lead to more refined criteria for defining a conserver.

Limitations of the Study

There are a number of points with respect to the study which require discussion. These points bear directly upon the internal and external validity of the experiment.

A major consideration is the selection of subjects for the study. School systems were selected on the basis of willingness to participate and adequate school population

size. While results may not generalize completely to subjects in other systems, research has shown, with some exceptions, a general trend toward little variation across different populations. Thus, the sample selected is not regarded as having major effects on the results even though complete randomization would be an improvement.

The difference in mean ages of second- and third-grade subjects suggests the possibility of maturation having possible effects on responses. However, it was revealed in Chapter IV that performance across the two grade levels was not statistically different.

For those subsamples to whom the group test was re-administered, the effects of taking the test previously were minimal. This is substantiated by Hypothesis III. The analysis of this hypothesis suggested that no significant practice effects were present. Since only five days elapsed between test and retest and since teachers were asked not to teach the conservation concept prior to retest, there is no reason to believe that subjects were overtly sensitized to the test. Similarly, there is little reason to suspect that interaction between subjects during the interval between test and retest had any significant effect on retest responses. Piaget et al. (1960) and others have shown that, prior to operational conservation, children are unconvinced by arguments about conservation when they do not see conservation as a logical necessity.

The testing of all subjects except those used for Hypotheses V and VI was performed by the experimenter. Thus, the experimenter variable was controlled to some extent. However, since there were different test groups involved, within experimenter variation could be only partially controlled. There were probably differences in voice inflection, subtle changes in experimenter movements, and possible differences in relative placement of the apparatus in the classrooms. It is suggested that audio-taped instructions coupled with a moving picture film presentation would provide more adequate control of these variables. It would be desirable to have several examiners randomized over treatments to provide additional control of the experimenter variable.

In connection with test administration, the seating arrangement of the subjects was considered important. A wedge-shaped seating configuration was used to control for possible differences in subject perception which might be due to seating. While it was not considered to be completely adequate, the same seating-perception problem may be present in a film presentation. However, the latter would appear to give better control than that achieved in this study.

Another aspect which requires control when a group testing format is used is that of subjects copying from one another during test administration. Some measure of

control for this was achieved by the "new game" format used to administer the tests. The experimenter emphasized that a subject should not look at his neighbors' papers because his answer was desired. This appeared to provide a measure of control over copying. Also, during test administration the classroom teacher was present. It is suggested that this procedure helped control copying to some extent.

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APPENDICES

APPENDIX A

RESPONSE BOOKLET, MATERIALS, AND INSTRUCTION DESCRIPTIONS

The response booklets for use with both COL8-2 and COL8-3 were five and one-half by eight and one-half inches. Each booklet consisted of eight pages. The last five pages were color-coded to correspond to orientation of rods or response breaker. The colors of pages two and three were chosen for efficient use of materials. Listed from left to right on the following pages are the pages of the response booklets, materials used with each "frame", and instructions received by the subjects for each "frame". Sequence 2 is illustrated below. Other sequences followed identical patterns except for page arrangement of the booklets.

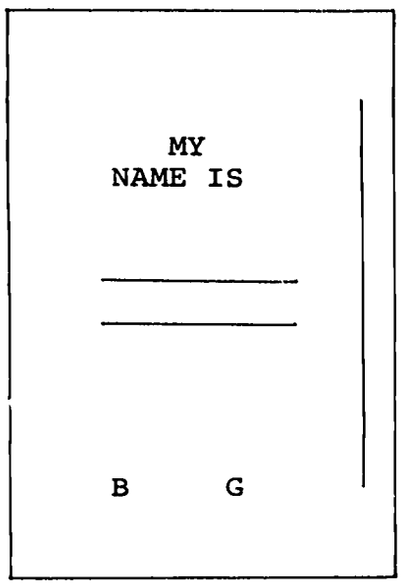


Figure A1.

Response Booklet Cover Page for COL8-2

Instructions

1. On this line (E points to one of the horizontal lines) write or print your first name. PAUSE. Now look at the bottom of the page. If you are a boy, draw a ring around the B. If you are a girl, draw a ring around the G.

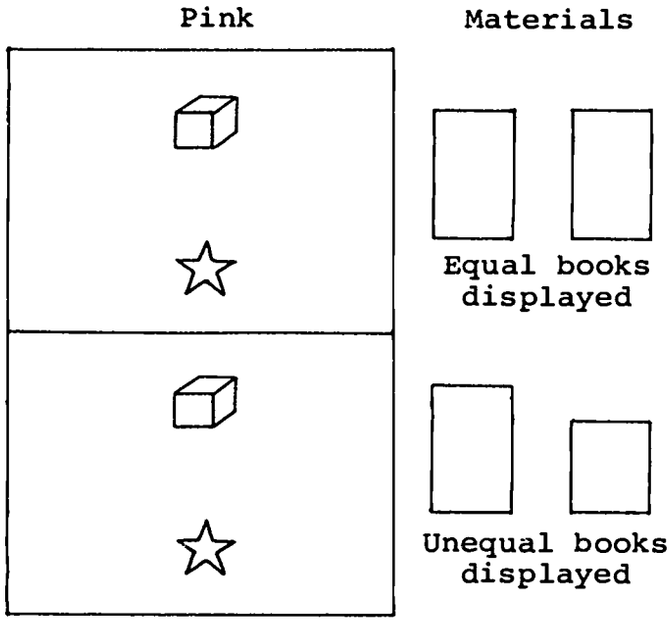


Figure A2.

Response Page and Materials for Items 1 and 2

Instructions

1. Here are two books. If you think these books are the same size, draw a ring around the box. If you think one book is bigger, draw a ring around the star. PAUSE. These books are the same size, see how they fit (E superimposing one book over the other)? You should have marked the box like this (E placing an oval over the box). If you didn't mark the box, do it now.

1. Here are two books. If you think one book is bigger, draw a ring around the star. If you think these books are the same size, draw a ring around the box. PAUSE. One book is bigger, see, they don't fit (E superimposing the smaller on the larger book). You should have marked the star like this (E placing an oval over the star). If you didn't mark the star, do it now.

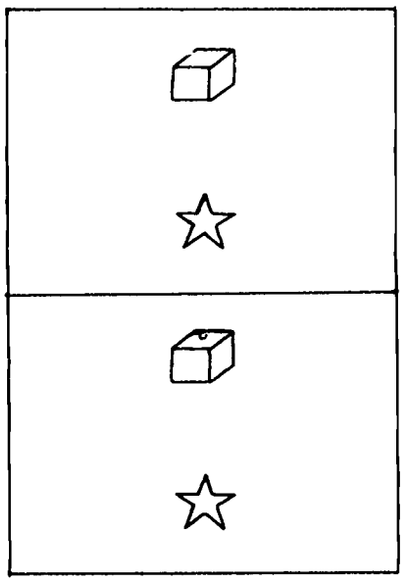
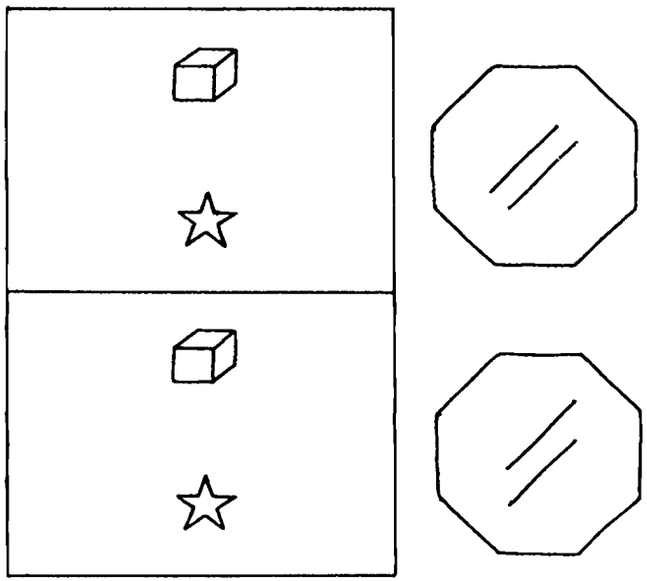
Yellow	Materials	Instructions
	Unequal rods displayed	Here are two rods. 1. If you think one rod is longer than the other, draw a ring around the star. 2. If you think both rods are the same length, draw a ring around the box.
	Equal rods displayed	Here are two rods. 1. Repeat instruction 2 of frame 1. 2. Repeat instruction 1 of frame 1.

Figure A3.

Response Page and Materials for Items 3 and 4

Pink Materials



Instructions

Here are two rods.
1. If you think both rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the other, draw a ring around the star.

NOW WATCH (Transformation)

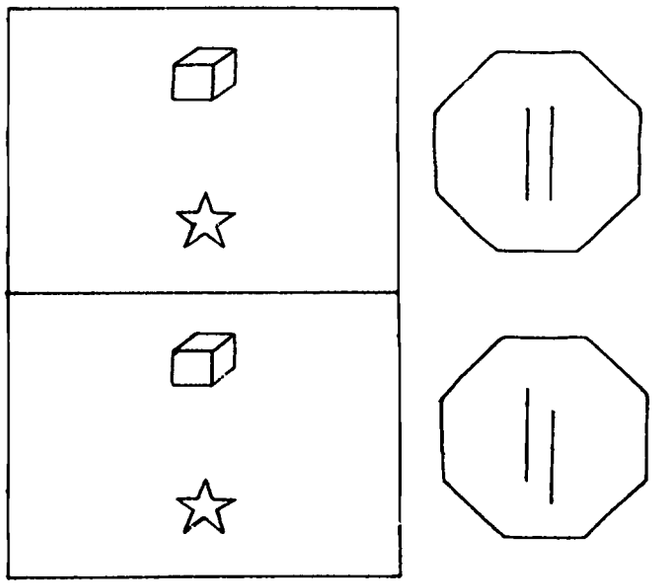
1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

Figure A4.

Response Page and Materials for Item 5

Blue

Materials



Instructions

Here are two rods.

1. If you think one rod is longer than the other, draw a ring around the star.
2. If you think both rods are the same length, draw a ring around the box.

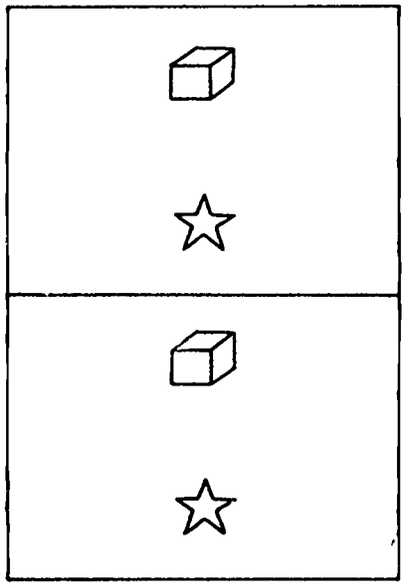
NOW WATCH (Transformation)

1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

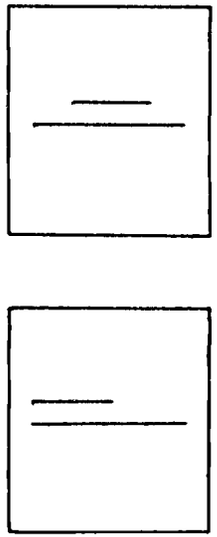
Figure A5.

Response Page and Materials for Item 6

Yellow



Materials



Instructions

Here are two rods.

1. If you think both rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the other, draw a ring around the star.

NOW WATCH (Transformation)

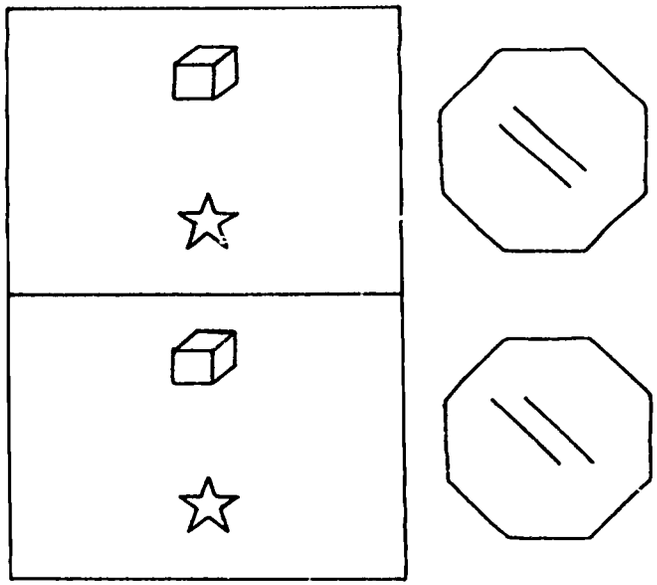
1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

Figure A6.

Response Page and Materials for Item 7

White

Materials



Instructions

Here are two rods.

1. If you think one rod is longer than the other, draw a ring around the star.
2. If you think both rods are the same length, draw a ring around the box.

NOW WATCH (Transformation)

1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

Figure A7.

Response Page and Materials for Item 8

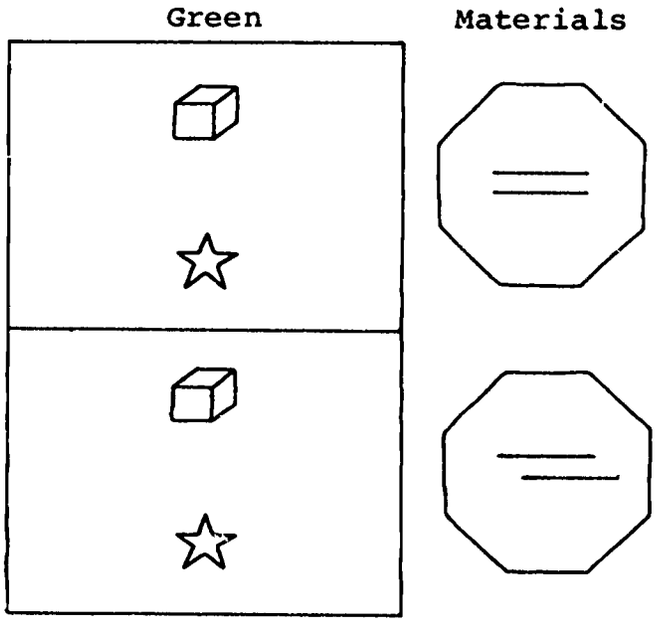


Figure A8.

Response Page and Materials for Item 9

Instructions

Here are two rods.

1. If you think both rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the other, draw a ring around the star.

NOW WATCH (Transformation)

1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

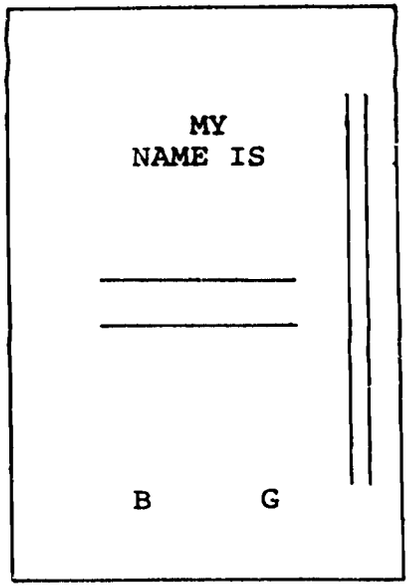


Figure A9.

Response Booklet Cover Page for COL8-3

1. On this line (E points to one of the horizontal lines) write or print your first name. PAUSE. Now look at the bottom of the page. If you are a boy, draw a ring around the B. If you are a girl, draw a ring around the G.

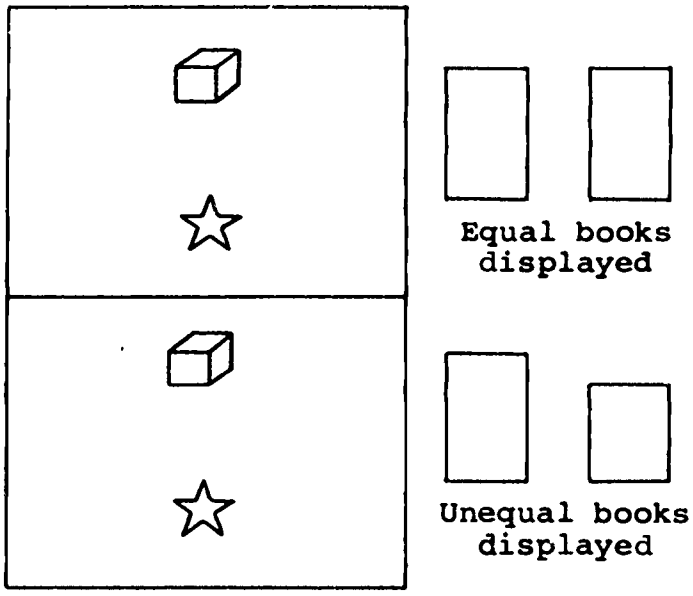


Figure A10.

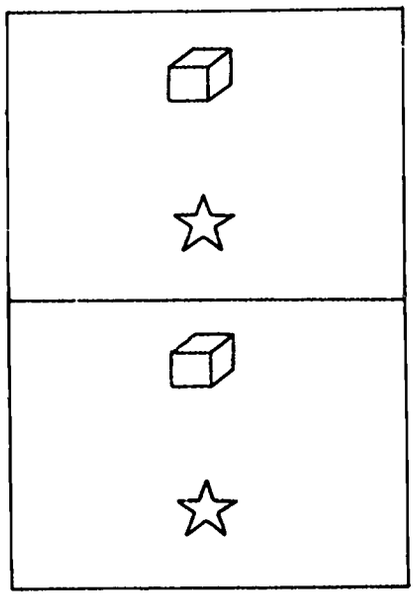
Response Page and Materials for Items 1 and 2

Instructions

1. Here are two books. If you think these books are the same size, draw a ring around the box. If you think one book is bigger, draw a ring around the star. PAUSE. These books are the same size, see how they fit (E superimposing one book over the other)? You should have marked the box like this (E placing an oval over the box). If you didn't mark the box, do it now.

1. Here are two books. If you think one book is bigger, draw a ring around the star. If you think these books are the same size, draw a ring around the box. PAUSE. One book is bigger, see, they don't fit (E superimposing the smaller on the larger book). You should have marked the star like this (E placing an oval over the star). If you didn't mark the star, do it now.

Yellow



Materials

Unequal rods displayed

Equal rods displayed

Instructions

Here are two rods.
1. If you think one rod is longer than the other, draw a ring around the star.
2. If you think both rods are the same length, draw a ring around the box.

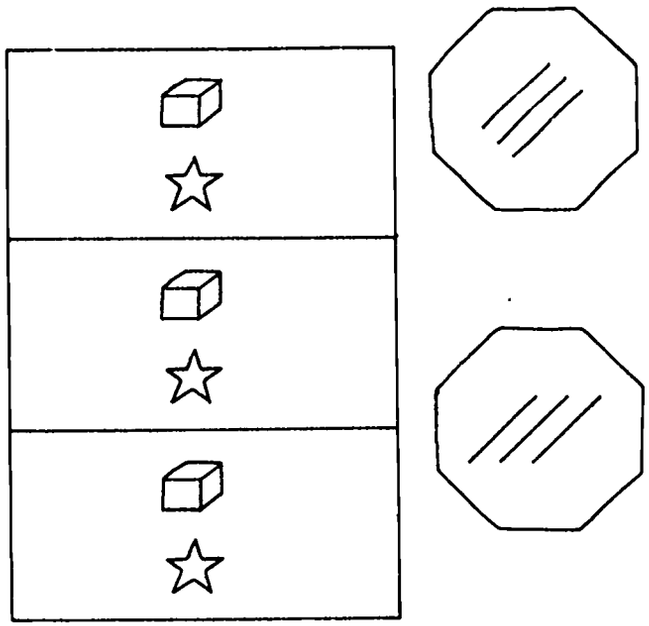
Here are two rods.
1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

Figure A11.

Response Page and Materials for Items 3 and 4

Pink

Materials



Instructions

Here are three rods.

1. If you think the rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the others, draw a ring around the star.

NOW WATCH (Transformation)

Look at these two rods (E points to left and middle rods throughout the frame).

1. If you think one rod is longer than the other, draw a ring around the star.
2. If you think these two rods are the same length, draw a ring around the box.

Now look at these two rods (E points to left and right rods throughout the frame).

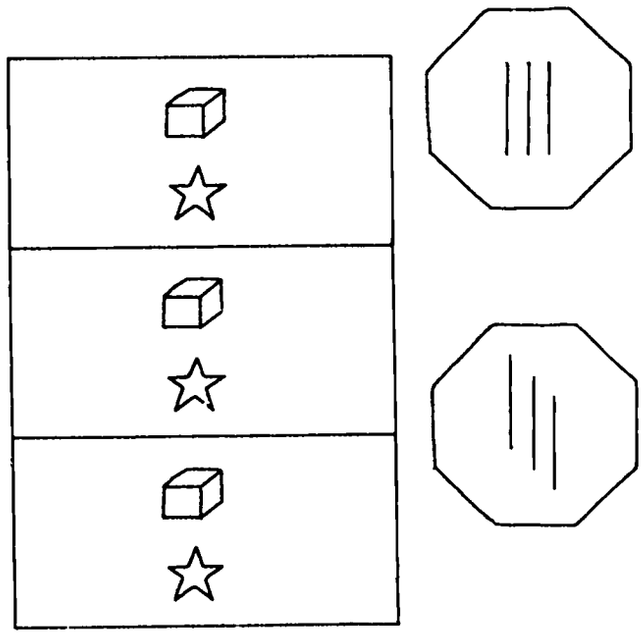
1. Repeat instruction 2 of frame 2.
2. Repeat instruction 1 of frame 2.

Figure A12.

Response Page and Materials for Item 5

Blue

Materials



Instructions

Here are three rods.

1. If you think one rod is longer than the others, draw a ring around the star.
2. If you think the rods are the same length, draw a ring around the box.

NOW WATCH (Transformation)

Look at these two rods (E points to middle and right rods throughout the frame).

1. If you think these two rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the other, draw a ring around the star.

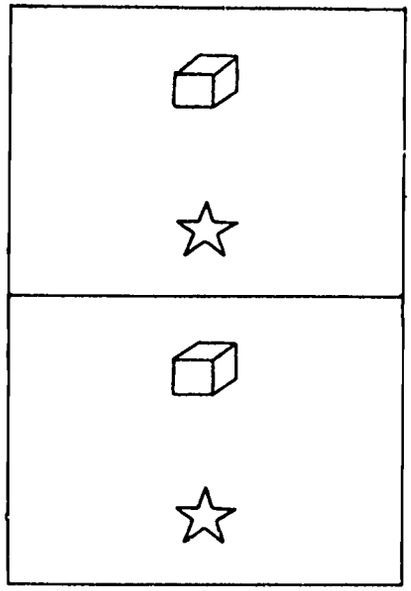
Now look at these two rods (E points to left and right rods throughout the frame).

1. Repeat instruction 2 of frame 2.
2. Repeat instruction 1 of frame 2.

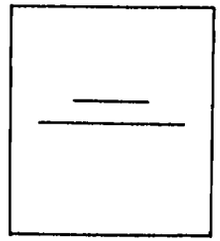
Figure A13.

Response Page and Materials for Item 6

Yellow



Materials



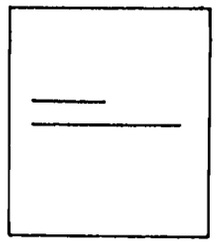


Figure A14.

Response Page and Materials for Item 7

Instructions

Here are two rods.

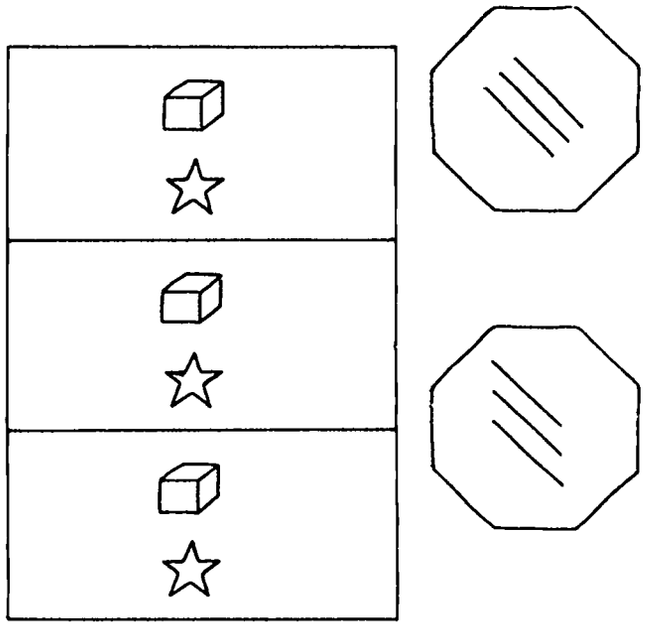
1. If you think both rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the other, draw a ring around the star.

NOW WATCH (Transformation)

1. Repeat instruction 2 of frame 1.
2. Repeat instruction 1 of frame 1.

White

Materials



Instructions

Here are three rods.

1. If you think the rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the others, draw a ring around the star.

NOW WATCH (Transformation)

Look at these two rods (E points to left and middle rods throughout the frame).

1. If you think one rod is longer than the other, draw a ring around the star.
2. If you think these two rods are the same length, draw a ring around the box.

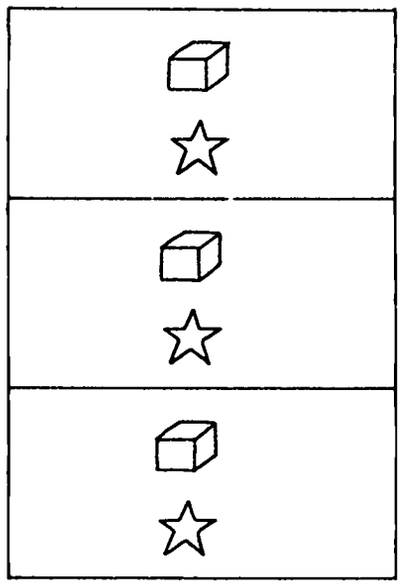
Now look at these two rods (E points to left and right rods throughout the frame).

1. Repeat instruction 2 of frame 2.
2. Repeat instruction 1 of frame 2.

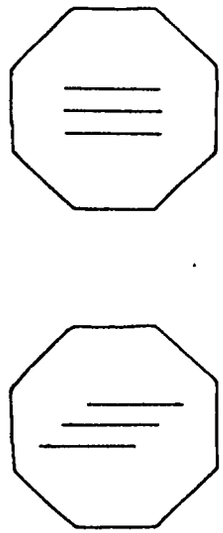
Figure A15.

Response Page and Materials for Item 8

Green



Materials



Instructions

Here are three rods.
1. If you think one rod is longer than the others, draw a ring around the star.
2. If you think the rods are the same length, draw a ring around the box.

NOW WATCH (Transformation)

Look at these two rods (E points to top and middle rods throughout the frame).
1. If you think these two rods are the same length, draw a ring around the box.
2. If you think one rod is longer than the other, draw a ring around the star.

Now look at these two rods (E points to top and bottom rods throughout the frame).
1. Repeat instruction 2 of frame 2.
2. Repeat instruction 1 of frame 2.

Figure A16.

Response Page and Materials for Item 9

APPENDIX B

Table B1.

Correlations of Grade Two Scores
With Total Test: COL8-2

Sequence	Orientation			
	0°	45°	90°	135°
1	.989	.989	.910	.989
2	.927	.920	.920	.900
3	.927	.917	.965	.965
4	.947	.941	.989	.989

Table B2.

Correlations of Grade Two Scores
With Total Subtest: COL8-3

Sequence	Orientation			
	0°	45°	90°	135°
1	.758	.866	.799	.853
2	.902	.806	.901	.864
3	.903	.901	.812	.835
4	.751	.822	.911	.878

Table B3.

Correlations of Grade Three Scores
With Total Test: COL8-2

Sequence	Orientation			
	0°	45°	90°	135°
1	.935	.975	.978	.978
2	.885	.834	.892	.920
3	.909	.944	.830	.944
4	.979	.979	.930	.831

Table B4.

Correlations of Grade Three Scores
With Total Subtest: COL8-3

Sequence	Orientation			
	0°	45°	90°	135°
1	.980	.908	.980	.890
2	.907	.804	.978	.978
3	.852	.881	.852	.934
4	.793	.855	.918	.895

Table B5.

Correlations of Second-Grade Scores
With Total Test: COL8-3

Sequence	Orientation							
	0°		45°		90°		135°	
	1-M	1-3	1-M	1-3	1-M	1-3	1-M	1-3
1	.827	.762	.834	.868	.772	.767	.847	.847
2	.912	.878	.847	.764	.874	.896	.893	.897
3	.626	.864	.793	.901	.198	.739	.889	.807
4	.825	.711	.886	.836	.884	.903	.858	.806

M - the unmoved standard rod of COL8-3

Table B6.

Correlations of Third-Grade Scores
With Total Test: COL8-3

Sequence	Orientation							
	0°		45°		90°		135°	
	1-M	1-3	1-M	1-3	1-M	1-3	1-M	1-3
1	.948	.960	.962	.885	.948	.960	.916	.849
2	.861	.887	.655	.812	.910	.961	.921	.961
3	.939	.814	.898	.883	.645	.856	.898	.898
4	.936	.773	.828	.828	.896	.936	.604	.884

M - the unmoved standard rod of COL8-3