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A Methodological Comparison of Interview and Behavioral Techniques for Assessment of Conservation of Length

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A METHODOLOGICAL COMPARISON OF INTERVIEW AND BEHAVIORAL TECHNIQUES FOR ASSESSMENT OF CONSERVATION OF LENGTH

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ABSTRACT

Piaget (1929) contends that a verbal interview is the only procedure which is flexible enough to follow and examine the development of cognitive processes in children. However verbal methods are inconsistent with the suggestion by Piaget (1951, 1963) and several colleagues (Furth, 1964, 1966; Sinclair-de-Zwart, 1969) that language merely reflects underlying cognitive processes, and is not a source of logical development. In addition verbal methods allow for verbal misunderstandings by both subjects and experimenters, provide for experimenter bias and may foster response sets.

To minimize these theoretical and methodological difficulties, several investigations (e.g., Braine, 1959, 1962; Sawda & Nelson, 1968) have employed nonverbal, manipulative techniques. None of these studies made direct comparisons of results from verbal and nonverbal methods; none entirely eliminated verbal interactions between subject and examiner.

This study presents a behavioral technique for the assessment of conservation of length based on operant work by Blough (1966) and Bijou and Baer (1966). It was designed to compare nonverbal results with results obtained in a Piagetian-type verbal interview, and to eliminate verbal interactions.

Thirty-two first grade children were evaluated individually by both verbal and nonverbal methods in counterbalanced order. First

graders were selected to insure both conservers and nonconservers in the subject population.

The verbal condition consisted of a Piagetian-type interview, although standardized questions were used so that every subject received the same interview. Four similar tasks were presented following Piaget's (Piaget, Inhelder & Szeminska, 1960) example.

In the nonverbal conditions, subjects were trained to press one button for stimuli of the same length and another button for stimuli of different length. Following training, subjects were exposed to eight test stimuli in which stimuli of the same length were staggered so that the end points did not coincide. In each condition subjects were required to make appropriate responses on 75% of the items to be considered conservers.

It was predicted that (1) nonverbal techniques would distinguish between conservers and nonconservers; (2) that verbal and nonverbal methods would yield similar decisions concerning the conservation ability of any particular subject; and (3) to the extent that the conservation decisions differed for any subject, nonverbal method would yield more and younger conservers than verbal methods.

With the exception of the predicted age difference, all hypotheses were supported. Reasons for failing to support the age hypothesis are presented. It was concluded that nonverbal techniques can be applied to Piagetian conservation tasks, and that such techniques are valid for the assessment of conservation. Results support Piaget's conservation of length construct and clinical methodology. The advantages of nonverbal methods are discussed and applications to nonverbal populations suggested. Limitations of the present study and suggestions for future research are presented.

CHAPTER I

INTRODUCTION

Developmental psychology has recently witnessed an increase in research relevant to Jean Piaget's theory of cognitive development. The thrust of much of this research has been to validate many of Piaget's constructs or processes. These studies generally assume one of three forms. One large body of research (Beilin, 1965; Gruen, 1965; Winer, 1968; Wohlwill & Lowe, 1962) attempts to validate Piaget's theory through learning, comparing spontaneous intellectual development with cognitive development as influenced by instruction. Piaget has described the general course of development; these validation studies attempt to induce cognitive development and then to compare the results with Piaget's predictions. Growing out of this work other researchers (Fleischman, Gilmore & Ginsburg, 1966; Roeper & Sigel, 1966; Smedslund, 1961a, 1961b; Wallach, Wall & Anderson, 1967) have attempted to isolate effective procedures for hastening development. This group frequently seeks to link Piaget with contemporary education, or to make inferences concerning curriculum development. A third group of studies (Elkind, 1961a, 1961b; Lovell & Ogilvie, 1961; Peel, 1959) has sought to replicate Piaget's work using larger samples and more rigorous controls.

It appears that a fourth type of validation study has been largely neglected, i.e., the study of Piaget's structures and processes using experimental methodologies other than those used by Piaget.

Investigations of this type have not been entirely absent as both Kofsky (1966) and Wohlwill (1960) have studied classification by scalogram techniques, while Braine (1959, 1962) and Sawda and Nelson (1968a, 1968b) have applied nonverbal, manipulative techniques to conservation tasks. Others have attempted to develop paper-and-pencil evaluation instruments (Delacy, 1967), to develop "conservation assessment kits" (Goldschmid & Bentler, 1970) and to quantify various tasks (Tuddenham, 1970). However, research of this type is infrequent and often cannot be generalized to the broader work of Piaget. Further, direct comparisons with Piaget's results are often avoided (e.g., Braine, 1959; Sawda & Nelson, 1968a, 1968b).

The investigation of Piaget's constructs using novel methods appears logically sound. If Piaget's theoretical formulations are valid, then they should be capable of examination by a variety of methods. Conversely, if cognitive structures postulated by Piaget are assessable only through Piaget's clinical techniques, then the theory lacks generality and is restricted in applicability.

The focus of the present study is to examine one of Piaget's major constructs--conservation of length--using a methodology which is completely divorced from Piaget's traditional data collection techniques. However, merely demonstrating the existence of Piaget's constructs in a new way is not sufficient to conclude that the underlying processes are the same. Validation appears to require a close comparison between the results of Piaget's work and any results from an alternative methodology. Consequently the present study seeks to compare structures as evaluated by an alternative methodology with those same structures as evaluated by Piaget's clinical methodology. Toward that end two methods of data collection--interview and behavioral--will be employed in assessing conservation of length in the same children, and the results compared.

CHAPTER II

REVIEW OF THE LITERATURE

Piaget's Theory

Piaget, an epistemologist, is not only one of developmental psychology's most prolific researchers, but also one of today's great theoreticians who has combined keen observation with logical explanation. Flavell (1963) writes that Piaget is "primarily interested in the theoretical and experimental investigation of the qualitative development of intellectual structures" (p. 15).

One of the fundamental assumptions of Piaget's theory (Inhelder & Piaget, 1969; Piaget & Inhelder, 1969) is that development proceeds in an orderly and predictable fashion through four qualitatively distinct stages or periods. Chronologically, these are (1) the sensorimotor stage which extends from birth to about two years of age; (2) the preoperational stage which includes the years from two to approximately seven; (3) the concrete operational stage which covers the period from seven years of age until about 11 years; and (4) the period of formal operations including the years beyond age 11. Several authors (Gouin Decarie, 1965; Flavell, 1963; Muller, 1969) combine the preoperational and concrete operational stages into a single stage with an initial period of elaboration and a concluding period of refinement. Although the order of appearance of the stage is constant, the time of appearance may vary with both the individual and the cultural milieu; therefore the ages presented above are approximations.

Each stage is characterized by the acquisition of intellectual operations which are regulated by the child's increasing ability to use complex operations already mastered. Each advance in development represents either a restructuring or a new structuring of elements which until that time have not been coherently related. In other words, development at any particular stage is largely dependent upon acquisitions in preceeding stages.

Development proceeds, according to Piaget, to the extent that an individual acts upon the environment to transform it, while at the same time modifying existent structures to meet environmental demands and eventually coordinating both transformations and modifications. Partial understandings are altered, broadened and finally coordinated in an attempt to achieve temporarily stable equilibrium in dealing with the environment.

Piaget views intellectual development primarily as a series of adaptations. He has discussed a number of factors contributing to intellectual development: maturation of the nervous system, encounters with the environment, social transmission, and equilibration. The first three factors assume that the individual passively undergoes changes and/or passively receives information. Only equilibration assumes that the individual is actively coping with his environment. Only equilibration assumes that the individual is adapting to inbalances in the system. Piaget does not deny that the other factors may make a contribution to the child's development, but contends that only equilibration is both a necessary and a sufficient condition for cognitive development. Since the equilibration process occupies a central position in Piaget's theory, the whole system is sometimes referred to as equilibration theory.

Borrowing from biology, Piaget phrases the equilibration process in terms of accommodation (modifications of existing mental structures) and assimilation (transformations of the environment) as complementary processes in the course of adaptation. Consequently, the child assimilates and accommodates as necessary in order to achieve new equilibria. Equilibrium is never permanent as the process continues in cyclic fashion.

A thorough explanation of Piaget's theory of cognitive development may be found in Flavell (1963), Hunt (1961) or Piaget & Inhelder (1969). Detailed descriptions of the stage development aspects of the theory are available in Piaget (1963) and Piaget and Inhelder (1969).

Conservation of Length

Conservation is a central construct in Piaget's theory. It represents a major difference between Preoperational cognitive functioning and Concrete Operational cognitive functioning. Piaget has noted that as the child gets older he comes to rely increasingly on abstract concepts such as volume, quantity, location, and weight, and relatively less on perceptual attributes of objects such as form and shape.

Piaget defines conservation as "the invariance of a characteristic despite transformations of the object or of a collection of objects possessing this characteristic" (1968, p. 978). Conservation of length, therefore, refers to the notion that objects retain their original length despite a transformation in spatial position.

Conservation of length is basic to all measurement according to Piaget (Piaget, Inhelder & Szeminska, 1960) who notes

> If in the course of movement, objects changed their length in an arbitrary manner, there could be no thought of a stable spatial field to act as a medium and reference system; and hence, there would be no stable distance relations between objects (p. 91).

Conservation permits an individual to construct a stable medium for distance reference. It also permits the recognition of the invariance of length in the course of positional change.

Piaget's interest in conservation of length grew out of several studies concerning development of spatial concepts in young children. Specifically, The Child's Conception of Space (Piaget & Inhelder, 1967) describes the development of notions of Euclidean geometry. These concepts represent elaborations of more elementary projective and topological concepts, according to Piaget and his colleagues. According to Piaget

> Topological and projective notions . . . are not enough to bring about this conservation. When children evolve topological nesting series by reuniting parts and reforming the original whole, they realize that a collection of elements remains the same collection even after its parts have been rearranged. . . . But this conservation of wholes does not imply that of length or distance. . . . Later the coordination of perspectives from different points of view enables the subject to reconstruct the order of parts in any direction, e.g., from left to right, or right to left. However, even now, the apparent length of these parts varies continually in the process (Piaget, Inhelder & Szeminska, 1960, p. 90).

Rather than being an extension of earlier mathematical concepts, the development of conservation of length requires the child to perceive distance as stable and symmetrical. Piaget et al. (1960) suggest

> the notion of distance, which allows the construction of a stable and homogeneous medium, also brings about the conservation of length in the course of positional change. That conservation is assured only if the site of an object maintains a constant size (i.e., its distance relation) when it is left empty, and the size of a site is not altered when occupied by an object (p. 91).

Piaget's preliminary work on the conservation of length focused on the determinants of children's judgments (Piaget et al., 1960). Subjects were asked to compare a straight line with an undulating line with regard to length. The lines differed in length, but the end points coincided. The authors (Piaget et al., 1960) report that 84% of those children younger than 54 months gave incorrect replies; of those children older than 66 months, only 10% gave incorrect replies. They concluded that the "length of a curvilinear shape is purely a function of its end points, or to be more exact, of its furthest extremity" (p. 93).

To expand on this preliminary investigation, Piaget and his colleagues embarked on a study of conservation of length. The investigation (Piaget et al., 1960) involved showing the subject two straight sticks identical in length; end points coincided during the initial presentation. Children were asked to compare the lengths of the sticks. Simple questions were used: "Are they (the two sticks) the same length, or is one longer than the other?" Piaget reports that children as young as four years judged the sticks as equal in length (Piaget et al., 1960).

Following the initial presentation and response, one of the sticks was moved to the left or right (sometimes more complex movements were used) approximately one-fourth the total length of the stick. The children were again asked which of the sticks was longer, or whether they were both the same length.

As a result of this investigation, Piaget has delineated three stages in the development of conservation of length (Piaget et al., 1960). The second of the three stages is further subdivided into two substages. However, in the most definitive statement on conservation of length (Piaget et al., 1960), Piaget fails to distinguish between Stage I and Substage IIA. In fact, in discussing the stages of development, Stage I and Substage IIA are presented together. The ensuing discussion follows Piaget's presentation (Piaget et al., 1960).

Stage I and Substage IIA: Nonconservation of length. Subjects in the first phase of conservation development estimate that the stick which has been moved forward is longer. They focus on the far extremities and ignore the near extremities. Below are several samples of Piaget's interviews with children in Stage I and Substage IIA:

> Ruf (4;6). Before staggering: "They're the same length. -(One stick is moved.) - It's bigger because you pushed it. The stick is longer."
> Rab (4;11): "They're the same length. -(After staggering.) -One is longer and the other is shorter."
> Wet (5;2): "They're the same. - (Staggered.) - That one is bigger because you moved it forward . . . (and this way) [both moved]. They're both bigger."
> Chat (7;0): "They're the same. -(Staggered.) - The one behind is longer (but he points to the end which projects in the other direction.)" (Piaget et al., 1960, pp. 95-96).

These responses illustrate how the youngest children are concerned with end points. The criterion is topological rather than Euclidean and the lines are liable to expand and contract without conservation. In other words, young children do not consider both ends simultaneously, and consequently, are not concerned with the distance between the endpoints.

The children's responses also illustrate a number of characteristics of the responding of nonconservers of length. The majority of children (Piaget et al., 1960) follow the moving stick, concentrating on the leading edge. Consequently, they ignore the compensatory withdrawal of the trailing edge. The stick is therefore judged to be longer because it extends further than the other with regard to the leading extremity. "At this level," according to Piaget et al. (1960), "change of position is considered purely as a change of order . . . such change must be judged to vary with the order of their leading extremities" (p. 97). The responses of Ruf and Wet are typical of children at this level. Clearly they are attending to the leading edge, and totally ignoring the trailing edge.

Other subjects concentrate on the trailing edge of the moving stick and therefore judge it to be shorter following the staggering. Although this response is rare, Chat shows this tendency in the above illustrations.

For another group of subjects, the judgement that one stick is longer is an automatic response to the change in position. These children do not even examine the end points, and frequently judge both sticks to be longer when both have been moved in the same direction. The response of Wet illustrates this mode of responding.

Substage IIB: Intermediate Responses. Children in the last half of the second stage show a variety of responses ranging from those noted above to correct replies. Conservation responses, when they do appear, are the result of "progressive regulations" in thinking; they are not yet operational (Piaget et al., 1960). The child in substage IIB is beginning to understand transitivity, and late in the stage begins to grasp measurement. His responses however are predominantly trial and error.

Below are examples of responses characteristic of Substage IIB.

Pel (4; 10). Extremities coincide: "They're both the same. - (Parallel with slight staggering.) - That one (which projects) is longer."- (Two equal sticks each measuring 7 cm. are substituted for the 5 cm. sticks and arranged so that their extremities coincide.) Is one of these two sticks bigger than the other? - "No they're the same size. - (Slight staggering though relatively less than before:) And now? - "They're also the same." - The same as before? "They're bigger than this way (without staggering) but the two of them are the same size."

Froh (5; 0). Two sticks 7 cm. long with extremities in alignment: "They're the same size." - And like this (staggered 1 cm.)? - "I think so (making certain by replacing one against the other!) Yes, the same. - And like this (one stick at 45° to the other and touching it midway)? - No that one (oblique, which projects beyond the other) is bigger."

Mil (5;6). Two 5 cm. sticks in alignment: "They're the same. (Staggered 1 cm.) - You pulled it, so that one is longer. (Staggering reversed.) - Now that one is longer. - (The sticks are realigned and then drawn apart simultaneously a distance of 1 cm. to the left and 1 cm. to the right respectively.) - It's the same, the strips aren't any longer. When you pull both of them they're the same length, but if you only pull one that one is longer."

Per (6;0). Staggered: "That one is longer. - (The other strip is drawn the same distance in the opposite direction:) Are they the same length or not? - No, they're both longer. That one is longer there (to the right) and that one is longer there (to the left). - Then are they or aren't they the same length? - (Hesitating): Yes."

Lob (7;2). After the usual type of response ("That one is longer", etc.) he ends by saying: "It looks longer, but it's the same thing after all." (Piaget, et al., 1960, pp. 98-99).

The intermediate responses of Substage IIB illustrate a number of transitory steps in the development of conservation. The first, according to Piaget et al. (1960) are perceptual judgments. These responses are independent of logic, and tend to bias responding in the direction of equality. Pel, for example, is convinced of the inequality of the 5 cm sticks, but when 7 cm sticks are substituted (and the 1 - 2 cm stagger is relatively smaller) he perceives the two sticks as equal.

A second transitory step relates to a decentering of attention. This is an intuitive conservation which releases the child from his dominant attention to the leading extremity. Thus Per notes that while one stick is longer to the right, the other is longer to the left.

A third transitory step, also based on intuition is illustrated by Mil, who conserves length when both sticks are moved simultaneously, but fails to conserve when only one of the sticks is moved. Piaget et al. (1960) note that this regulation is somewhat more advanced than the intuitive judgments of Per.

A number of subjects note that the sticks are equal when arranged in exact alignment, but are not sure that the equality is maintained when the sticks are staggered. In order to convince themselves of equality of length they realign the pair of sticks. Piaget et al. (1960) note that this "method of verification does not imply operational reversibility, and is no more than an empirical or intuitive return to the starting point" (p. 100).

In a final step, the child is persuaded by his conflicting intuitions that the stimuli do remain the same. At this point they must dis-associate the reconstruction of reality from their perceptual and intuitive constructions. Thus Lob ends by saying, "It looks longer but it's the same thing after all."

These conservations are based on trial and error and are not yet operational. Piaget et al. (1960) note that the children at Substage IIB

> guess at conservation, without basing this notion on an exact composition of the spaces left empty by the change in position of the test objects and the corresponding spaces which are occupied: they do not realize that in every change of position these two factors are mutually compensating (p. 101).

In other words, in Substage IIB the thought of the child does not consider fixed sites, but deals only with the transformations of objects. This limitation precludes operational conservation of length (Piaget _et al._, 1960).

Stage III: Operational conservation. In the third stage the children use both stationary sites and moving objects; as a result conservation is logically necessary, and no longer merely a hypothesis.

Below are a number of illustrations of Stage III responses:

> Sol (6;7) Two sticks with a stagger of 1 cm.: "It's always the same length. -How can you tell? - There's a little (empty) space there (difference between the leading extremities) and there's the same little space there (difference between the trailing extremities)."
>
> Dim (7;0) Stagger: "They're both the same but they're placed differently. - How can you tell they're the same? (Indicated the interval between the leading and the trailing extremities)."
>
> Cal (7;7) "They're still the same, they can't grow! With various arrangements. They're always the same length and they'll always stay the same." (Piaget _et al._, 1960, p. 101).

The response of Dim is interesting, in that he notes that the stimuli "are the same, but they're placed differently." Piaget _et al._ (1960) note that a change in position may refer to a change in spatial relations between objects (in which event either or both could undergo expansion or contraction), or it could refer to a change in location, which exists independently of the object itself. Dim appears to be referring to the latter, and it is this understanding of "change of position" which is essential to conservation.

Sol makes use of these "locations" as invariant points when he comments on the "little space" between the two leading edges and the same "little space" between the two trailing edges.

Conservation of length is thus dependent upon the development of a stable reference system. Piaget _et al_. (1960) conclude

> Thus, there can be no conservation of length . . . unless there is a reference system which provides a common medium for all objects, whether moving or stationary and this in turn implies that there must be composition as between objects and their parts, and empty sites (p. 103).

Although conservation of length represents a major achievement for the child relatively little research has been done attempting to replicate Piaget's (Piaget _et al_., 1960) work. Most of the validation work has focused on induced conservation of length.

Beilin and Franklin (1962) looked at the effects of instruction on measurement and conservation of length and area. Following a pretest for ability to conserve and measure lengths and areas, half of the Ss were instructed in concepts and skills of measurement and conservation by means of concrete examples. Instruction was a group procedure and consisted of only one session. Other Ss received no instruction. Both groups showed improvement on a posttest, which is reported to be an alternate form of the pretest. Beilin and Franklin suggest that the pretest may have constituted a training situation to account for control group improvement.

A more relevant finding concerns the simultaneity of the development of conservation and measurement of length and area. Although Piaget _et al_. (1960, pp. 285, 300) reported that conservation of length and area are simultaneous events in ontogenetic development, Beilin and Franklin failed to support those findings. They suggest that conservation and measurement proceed from one dimensional figures to two dimensional figures, and finally to three dimensional figures. In other words, the child first learns to measure and conserve length, then area, and finally volume.

Kingsley and Hall (1967) attempted to improve conservation of length performance for five and six year olds using Gagne's (1970) hierarchical approach. Items from the hierarchy include:

1. Know the meaning of appropriate terms, i.e., longer, shorter, etc.
2. Know how to measure length with an independent third measuring instrument.
3. Know that use of a measuring stick is more accurate than visual cues.
4. Know the effect of adding and subtracting at the ends on length.
5. Know the effect of moving the object on length regardless of other extraneous cues (Kingsley & Hall, 1967, p. 1114).

Analysis of the results yielded highly significant training effects. Kingsley and Hall conclude that the "task analysis proved to be very effective in defining behaviors which were needed for successful mastery of conservation" (1967, p. 1125).

Two other studies (Smedslund, 1964; Goldschmid, 1967) have attempted to relate conservation of length to both subject characteristics and other conservation tasks. In a broad study of the development of concrete reasoning, Smedslund (1964) sought to determine the interrelationships of various abilities necessary for concrete reasoning. He developed a number of items adhering to rigorous standards designed to "maximize their diagnostic validity" (p. 4). Using these items, he analyzed class inclusion, multiplication of classes, reversal of spatial order, conservation of discontinuous quantity, multiplication of relations, transitivity of length, conservation of length, addition and subtraction of units, and transitivity of discontinuous quantity.

He (1964) concluded that concrete reasoning has a "very limited generality during the period of acquisition. It seems to be acquired in one restricted situation at a time. . ." (p. 26). In spite of some inconsistencies in the data, he also concluded that conservation and transitivity of quantity precede conservation and transitivity of length. This conclusion is in agreement with the conclusions of Beilin and Franklin (1962).

In an ambitious study, Goldschmid (1967) compared conservation of substance, weight, continuous and discontinuous quantity, number, area, distance, length, two- and three-dimensional space in relation to age, sex, IQ, MA and vocabulary. In the test of conservation of length, Ss were confronted with two sticks of identical length which were laid side by side so that their extremities corresponded. After S confirmed that the sticks were of the same length, one of the objects was moved to the side, so that the leading edge was approximately one inch ahead of the other stick. S was again asked to compare the lengths. After the sticks were matched again, Mueller Lyer arrowheads were applied to make the stick look longer, and then in a second transformation, shorter.

Goldschmid (1967) reports that the tasks fall into the following order in terms of difficulty (from least to most difficult):

1. Substance
2. Number
3. Continuous quantity
4. Two-dimensional space
5. Discontinuous quantity
6. Weight
7. Area
8. Length
9. Three-dimensional space
10. Distance (p. 1235).

These findings conflict with Beilin and Franklin (1962) who suggest that conservation of length is easier than conservation of two-dimensional space.

Goldschmid also reports that conservation of length correlates .37 ($p \leq .001$) with mental age, .21 ($p \leq .05$) with IQ, and .27 ($p \leq .01$) with vocabulary. He found no significant differences between males and females.

In summary, a number of studies have been conducted relative to conservation of length, although the number is relatively less than the number of studies on other conservation tasks. Some of these have focused on validation by means of induced conservation (Beilin & Franklin, 1962; Kingsley & Hall, 1967), while others have attempted to describe the conservation of length task in terms of subject variables (Smedslund, 1964, Goldschmid, 1967). None of the studies have attempted a direct replication of Piaget's work reported in *The Child's Conception of Geometry* (Piaget *et al*., 1960). While the studies do indicate some minor inconsistencies, particularly with regard to the order of appearance of some conservation abilities, they generally support Piaget's description of the development of conservation of length (Piaget *et al*., 1960).

Piaget's Research Methods

While Piaget has been original and insightful in his research, he has frequently been less than careful in the design and execution of his studies. One need not study Piaget in any great detail to discover a number of weaknesses. Flavell (1963) in his balanced critique of

Piaget, divides the criticisms into two categories: (1) complaints, and (2) problems.

Complaints, or "bad habits" as Flavell sometimes calls them, are recurrent shortcomings which appear throughout the system. Generally, these practices are clear-cut weaknesses, rather than differences of opinion among researchers. At least three types of complaints of this nature are evident: (a) matters of theory, (b) matters of experimental design and data analysis, and (c) interrelationships between theory and data (Flavell, 1963).

With regard to theory and interpretation, perhaps the most frequent criticism of Piaget is his ponderous, complex style of writing. Most students of Piaget would agree that he is unnecessarily difficult to read. Other complaints in this category refer to Piaget's tendency to elaborate on theory either with little or no empirical support, or without linking theoretical conclusions to the data. Flavell (1963) concludes that "Piaget manages to end up with what looks like a considerable amount of theoretical excess baggage . . . in surplus of whatever may be genuinely valuable in describing or explaining behavior . . ." (p. 428).

The second category of complaint refers to matters of experimental design and data analysis. Criticisms of this sort concern the experimental techniques Piaget uses in conducting his research. Perhaps the most important shortcoming is his failure to report exactly what he did in an experiment. Frequently the tests employed, the scope of the study and the goal of the verbal inquiry are omitted entirely. On occasion illustrative examples are included, but even these are often presented without explanation or introduction, and generally without consideration of what preceeded. Seldom, if ever, is an exact copy of a complete interview offered. Braine (1962) complains that Piaget "never reports his data fully, but rather illustrates with samples" (p. 42). Criticisms in this category appear to be at least partially a result of Piaget's expousal of a "clinical methodology" (Piaget, 1929). The relationship between theory and data is the third type of complaint lodged against Piaget. In Piaget's system the relationship is often fragile and frequently ambiguous. He tends to over-interpret, often stimulated by inconclusive data. Flavell (1963) notes that "a given quantum of evidence, shaky or solid, is frequently a stimulus for what appears to be an excessively verbose and overelaborated theoretical discussion" (p. 433). Ahr and Youniss (1970) go one step further in analyzing the class inclusion problem. They note that "Piaget's analysis of class inclusion behavior was probably correct theoretically but was in need of methodological explication" (p. 132).

Flavell's (1963) other category of criticisms deals with problematic issues in Piaget's research and theory building. These issues are more a matter of debate and evaluation than unquestioned gaps in the system. One of the criticisms in this category is that Piaget has over-structured the thinking of the child.

A second issue, more relevant to the present study, concerns the use of language. Berko and Brown (1960) have argued that many of Piaget's studies are merely growth studies in disguise. Piaget's tasks often purport to assess the child's understanding of words like "more," "less," "all" and "some." As might be expected the young child shows an incomplete understanding of such terms which only gradually approaches that of an adult. At one point Berko and Brown (1960) assert that "Piaget is inclined to see through words as though they were not there and to imagine that he directly studies the child's mind" (p. 536). In fact it is apparent that Piaget is often studying the child's comprehension of verbal utterances.

In summary, much of the criticism that has been directed at Piaget's research is an outgrowth of his clinical methodology. Specifically, criticism centers on the verbal interaction between examiner and child which is required in the clinical interview.

The Clinical Interview

Piaget's data collection techniques vary considerably with the task under investigation. For example, his methodology in treating perceptual development is vastly different from his methods for studying cognitive development (Flavell, 1963). Even within the area of intelligence there is considerable diversity with regard to the technique used in evaluation.

In some major works on intelligence (Piaget, 1926; 1951; 1963) Piaget merely recorded ongoing behavior. Although such observations appear accurate and objective, they have involved few subjects, no experimental intervention and no systematic categorization of the content of narrative recordings. A large number of studies, however, do have the formal characteristics of experiments in that the behavior under study is elicited by a stimulus controlled or provided by the experimenter.

In many of Piaget's early writings both the stimulus (or stimuli) presented by the experimenter, and the response emitted by the child were entirely verbal. Frequently, the verbal exchange concerns events or stimuli which are neither described in the conversation, nor discussed in the introductory material. Flavell (1963) suggests four varieties of stimulus situations appear in Piaget's writings: (1) verbal behavior concerning remote events; (2) verbal behavior concerning immediate events; (3) mixed verbal and non-verbal behavior; and (4) non-verbal behavior. Further, he concludes that

> Piaget's methods of studying cognitive development almost always include some verbal, interview-like component whereever questioning is feasible. Piaget has tended, however, in the post-1930 work to favor experiments which are not wholly verbal (Flavell, 1963, p. 27).

However, even in those studies using behavioral components, the actions of the child are initiated at the request of the experimenter and require the child to understand the verbal instruction. Thus, while the child may do one thing and say another, both behaviors are dependent upon the instructions of the experimenter and more or less related to the task at hand.

Certain characteristics are common to all of Piaget's investigations which go beyond the observational level. Initially, the child is confronted with some kind of task to which he makes some kind of a response. Following the child's response, the experimenter asks a question, poses variations of the problem, offers hypothetical responses or alters slightly the stimulus situation. In other words the experimenter selects some aspect of the child's response with an aim towards clarifying the cognitive structures underlying the original response. The interview continues with each successive question being partially determined by the child's previous justification. Since the interview is flexible, designed to follow the course taken by the child's responses, no two subjects ever receive exactly the same experimental treatment. Piaget's failure to maintain constant procedures from subject to subject has been a source of irritation for several researchers (Braine, 1962; Flavell, 1963; Zimiles, 1963).

In his early writings, Piaget (1929) maintained that an interview-like technique was the only method suitably flexible to follow the thought of the child. In the context of following hunches and ideas growing out of careful observation of children's spontaneous behavior, the interview technique does appear valuable. However, once basic variables are known, more systematic experimental research would appear desirable. Even in the absence of large numbers of subjects and complex experimental designs, accurate and complete descriptions of the experimental situation would facilitate further study of cognitive development. Also, in the case of Piaget's research, more careful and systematic research, and more thorough reporting of results would facilitate replication. Although Piaget admits the usefulness of standardized procedures (1929, p. 3) he continues to use techniques which are predominantly verbal.

Braine (1962) suggested that Piaget's goal is to diagnose the intellectual processes available to the child. Flexibility in procedure facilitates the diagnostic process by permitting detailed inquiry into specific responses. No doubt Piaget feels that standardization would impair the diagnostic process through loss of individual information, thereby making the results less representative of an individual child. Piaget writes, "statistical precision could no doubt be easily obtained, but at the cost of no longer knowing exactly what was being measured" (Piaget, 1965, p. 149).

Piaget refers to his methodology as the "methode clinique" (clinical method) and notes its similarity to psychiatric procedures (1929). Its crucial importance, as stated previously, stems from the ability to follow, explore and stimulate diverse behaviors. As suggested above, Piaget contends that only through such a method can the investigator pare away the excess and get to basic cognitive structures. However, Piaget is not unaware of the hazards of the clinical approach:

> It is hard not to talk too much when questioning a child, especially for a pedagogue! It is so hard not to be suggestive! And above all it is hard to find a middle course between systematization due to preconceived ideas and incoherence due to the absence of any dictating hypothesis! The good experimenter must, in fact, unite two often incompatible qualities; he must know how to observe . . . to let the child talk freely without ever checking or sidetracking his utterance, and at the same time he must constantly be alert for something definitive (Piaget, 1929; p. 9).

However, Piaget neglects those hazards which are most pertinent to methodology, and ignores those which limit or hinder the extension or validity of the theory.

The second disadvantage of Piaget's clinical method, the possibility for the introduction of bias through the use of language, has been mentioned previously. Piaget himself seems to have recognized the problem as early as 1929 when he suggested that the "child neither spontaneously seeks nor is able to communicate the whole of his thought" (p. 6). In light of such a definitive statement, it is curious that Piaget continues to employ predominantly verbal methods. Such realizations, however, have not affected Piaget's methods significantly.

Piaget's emphasis on verbal inquiry appears even more inconsistent in light of the fact that he does not consider language to be a sufficient condition for the construction of intellectual operations (Piaget, 1951, 1963; Inhelder & Piaget, 1969; Piaget & Inhelder, 1969). Instead, he contends that (1) preverbal, sensorimotor behaviors structure future representational intellectual operations; (2) language is structured by logical and intellectual operations rather than the converse; (3) language may increase the range and rapidity of thought, but only in the advanced stages of formal operations (Piaget et al., 1969).

Furth (1964, 1966, 1969) reached similar conclusions after extensive research with deaf children. He reported that deaf children acquire elementary logical operations in the same sequence as normals and with only slight retardation. This work suggested that symbolic functioning is necessary for the construction of cognitive operations, but that the symbolic functioning need not approach the organization of language. Furth (1964) concluded that "the ability for intellective behavior is seen as largely independent of language" (p. 162).

Recent work by Sinclair-de-Zwart (1969) has lent additional support to the proposed dependence of language on logic. She concluded that "language is not the source of logic, but is on the contrary structured by logic" (p. 325).

In light of the evidence for the development of language as an outgrowth of logic, the incongruity of Piaget's methodology is obvious. If language does develop separately from cognitive operations, how can verbal methods accurately assess the cognitive structures which the child possesses? If intellectual development precedes language development, as is suggested by Piaget's reduction to sensorimotor development, then verbal inquiry can only reflect those cognitive structures which also appear in language symbols. Even if intellectual and language development are simultaneous, verbal methods only indirectly indicate those cognitive structures which are available to the child. Obviously either situation allows for considerable inaccuracy and confusion by both the subject and the examiner.

In summary Piaget's preference for a loosely formulated semi-anecdotal method of data collection is not a haphazard choice. Rather it is the result of considerable experience and thought. His decision to use verbal methods is predicated on the conviction that such a method has several advantages unavailable with other methods. Piaget comments on the misuse of the clinical method in the natural tendency to overstructure the situation. He appears to ignore the difficulties his methods pose for replication and/or validation. He appears equally oblivious to the contradictions between theory and methodology with regard to the relationship between language and intellectual development.

A number of studies (Braine, 1959; Delacy, 1967; Sawda & Nelson, 1968a, 1968b) have attempted to minimize the weakness of the clinical method in examining conservation of length. All of these studies have reduced the verbal requirement to a minimum, and have eliminated the verbal justification.

Braine's monograph (1959) described an experiment on the transitivity of length using a predominantly nonverbal procedure. Ss were trained for a candy reward to select the longer (or the shorter) of two upright sticks. Following this training, they were tested for the ability to infer that an upright (A) was longer than a second upright (C) when the difference was imperceptible. Further the inference was based on the observation that upright A was taller than B which in turn was taller than C. The nonverbal reinforcement procedure elicited transitivity earlier than Piaget's original method. Also, those children capable of transitive inference made more precise length comparisons in a perceptual situation (when the transitive inference was not possible) than did children who did not make transitive inferences originally. This finding supports Piaget's contention (Flavell, 1963) that perceptual development interacts with cognitive development.

Sawda and Nelson (1968a) devised a technique for assessing conservation of length which attempted to control for guessing, perceptual estimation, misunderstanding of instructions, misconception of the response criteria, failure to perceive the initial comparison of lengths, lack of a verbal way of expressing decisions, and disinterested performance. They provided the Ss with calipers which fit stimulus objects in one of three ways: perfect fit, 5 cm too long, or 5 cm too short. During training Ss were showed how to use the calipers and apply them to the stimuli. Ss were then asked to indicate which of three "model fits" the example resembled. Correct replies resulted in a candy reward; incorrect replies were corrected by encouraging the Ss to attempt the task again. Following training Ss were given a number of stimulus objects which were transformed by (1) rotation, (2) translation, (3) addition or subtraction of a portion. Of 24 test items used, 16 left the stimulus object invariant, while eight resulted in changes.

Sawda and Nelson reported that the conservation threshold occurs at about five and one-half years, or about two years earlier than Piaget et al. (1960). However, they failed to make any direct comparisons with Piaget's clinical method. Instead they relied entirely on Piaget's age analysis which most authors agree is merely an approximation influenced by many variables (Flavell, 1963; Guinsburg & Opper, 1969). Further, it is somewhat doubtful that Sawda and Nelson are even assessing conservation. More likely they are examining the child's ability to use an independent measuring tool. While this usage has been a subject of investigation for Piaget (1953) and while the age of appearance is approximately the same as for conservation (seven to seven and one-half years), it does not require the same operations as conservation.

In a second study Sawda and Nelson (1968b) examined the relative importance of "states" and "transformations" in the ability to conserve. Using the nonverbal techniques described above they concluded that states and transformations are equally important in the acquisition of conservation.

Delacy (1967) reported an attempt to measure conservation of length using a paper-and-pencil test. Ss were shown two equal lines and asked to compare them; Ss who indicated that the lines were different were asked to measure them. Mueller-Lyer arrowheads were superimposed on the lines and Ss were again asked to compare the lines. Delacy noted that conservation of length generally appears between six and eight years of age, a finding in agreement with Piaget et al. (1960). However, because of an inversion in the data, she concluded reliable estimation of conservation of length was not possible until age 12.

In summary, of four studies (Braine, 1959; Delacy, 1967; Sawda & Nelson, 1968a, 1968b) purporting to use nonverbal methods in the assessment of length, not one of the studies provided a direct comparison of results with results from a Piagetian-type interview. Rather all used age approximations which have been described as subject to considerable variation. Not one entirely eliminated the verbal interaction between S and the examiner concerning the conservation task.

A Behavioral Alternative

Because of the weaknesses in the clinical methodology, principally resulting from the verbal interchange, an ideal alternative would employ nonverbal techniques of data collection. Braine (1962) suggests that nonverbal procedures are valuable in verifying Piaget. However, he also suggests that such methods are antagonistic to Piaget. This would appear to be the case only with regard to the basic research orientation espoused by Piaget. Piaget acknowledges the use of standardized testing procedures, but feels restricted in using them. He does not reject them entirely, but prefers to use more flexible methods in his investigations.

Kohnstamm (1967) also noted the possibility of using behavioral methods in assessing Piagetian tasks. However, he has cautioned that the Genevans are reluctant to accept such work whether positive or negative.

Although the use of nonverbal methods is not new, previous nonverbal evaluations have been more manipulative than ideal. Braine (1959, 1962) for example has used nonverbal techniques. However, his methodology involves allowing the subject to make several manipulations of the stimulus items, but generally in response to some specific verbal instruction from the examiner. Thus, although Braine minimizes the need for the child to justify or explain his responses, and provides for considerable behavioral observation, he does employ verbal instructions and thereby allows for misunderstanding by the subject.

Behavioral methods have an important advantage over clinical methods: they eliminate or reduce the need for verbal understanding, instruction or interaction between subject and examiner. Bijou and Baer (1966) suggest that "experimental investigations with children have not been characterized by careful control over physical and social stimuli" (p. 722). These remarks appear especially appropriate to much of Piaget's research as well as the work of both colleagues and critics. Bijou and Baer (1966) further suggest that since

> children represent a species highly sensitive to social reinforcement, and indeed represent an age in which their parents . . . typically are striving to implant and develop this sensitivity, it is clear that unrecognized social reinforcement contingencies may abound in almost any experimental situation (p. 722).

Both Bijou and Baer (1966) and Blough (1966) have presented operant means for data collection which offer interesting alternatives to Piaget's techniques. Further these methods are primarily behavioral and only minimally verbal. Since the techniques were orignally developed for animal studies (e.g., Skinner, 1938) and later modified for sensory investigations in animals (Blough, 1966), they are at least logically appropriate for nonverbal investigations with children, and free of many of the verbal restrictions of other methods. As a method for assessing Piagetian tasks, operant methodology has been overlooked.

Essentially the behavioral method involves the substitution of a distinctive nonverbal response (operant) for each of the complex verbal responses present in the clinical interview. Consider an example from everyday life. In response to feelings of hunger, a child might say, "I want something to eat." Or he might clap his hands together. Obviously the operants differ in complexity and in development, but this does not alter the basic similarity. In either case if the response should be reinforced (as by the acquisition of food), the response becomes more probable in the presence of the same or similar stimuli.

In this example the important stimulus would appear to be some internal stimulus such as stomach contractions which serves as a discriminative stimulus (S^D). In the presence of the S^D the child makes the appropriate response--either verbally or nonverbally--and is reinforced. In the absence of the discriminative stimulus (S^Δ) the child is not reinforced for his responses, although responses may be emitted. Eventually responding comes under stimulus control and appears only in the presence of S^D, or at a higher rate than in the absence of S^D.

The same type of analysis may be applied to the conservation of length problem. If the child possesses a concept such as conservation of length, then a number of operants are brought under the control (perception) of the relevant stimuli. Recognizing that two stimuli are of the same length the child might say "They are the same length." However, there is no reason why he could not make an appropriate nonverbal response to the same discriminative stimuli.

Thus it is assumed that if the child possesses a particular concept (e.g., conservation of length), he may associate elements of that concept with an operant--verbal or nonverbal--through reinforcement. The child, therefore, is not learning a new concept, but is learning a socially meaningful label for his concept, or for elements of that concept. The label may be either verbal or nonverbal. In the suggested alternative methodology, the child is not learning to conserve, but is learning to make a particular response (nonverbal) to replace the verbal response normally made in the clinical interview.

A Behavioral Analysis of Conservation

In the standard Piagetian conservation of length task a child observes two stick-like objects, which may or may not be identical in form, length or alignment. In response to the question, "Are these two sticks the same length, or is one longer than the other?" the conserver replies that the two are the same. (A nonconserver would either reply incorrectly that the two sticks are not the same, or would respond inconsistently.) A Piagetian would interpret this behavior as indicating that the child possesses certain logical operations which allow him to conserve length. Advocates of a non-mediational stimulus-response position (e.g., Bijou & Baer) would interpret the behavior as indicating that the child has a reinforcement history for responding as above in similar situations.

One need not translate Piagetian concepts into stimulus-response terminology as Berlyne (1962) has done in order to analyze the conservation problem operantly. What is necessary, and what is attempted in the following paragraphs, is an exploration of a possible nonverbal response and examination of the stimulus context in which the behavior would occur.

As mentioned previously, any behavior could be substituted for the complex verbal response required in clinical methods. For example, a child might press a lever, or push a button rather than say, "The sticks are the same." Further, he might press a second lever, or push a second button for the situation when the sticks are not the same. In the verbal condition the child apparently has a reinforcement history for an appropriate verbal response (regardless of accuracy), while in a nonverbal situation, the child would apparently have a reinforcement history for making an appropriate nonverbal response.

The second requirement in the application of behavioral methods to the conservation problem is a specification of the stimulus context so as to identify those variables controlling the responding. The conservation of length problem is readily divided into two stimulus components: the situation when the stimulus objects are (or are perceived as) the same length; the situation when the stimulus objects are not (or are perceived as not) the same length. In other words, the only responses it is necessary for the child to make are one for the situation when the stimuli are perceived as similar, and a second when the stimuli are perceived as dissimilar with regard to length.

From a stimulus-response point of view one purpose of the analysis of a particular response is to determine the controlling or discriminative stimulus (or stimuli) for the occurrence of that response. Generally it is assumed that a stimulus controls behavior either because it has an unconditioned power to elicit that behavior, or because previous emissions of the behavior, occurring in the presence of the stimulus, have been reinforced. A verbal behavior, especially a rather complex verbal response such as "The sticks are the same length" cannot be considered to be an unconditioned reflex behavior. Such a behavior has probably been reinforced in the presence of discriminative stimuli, and therefore differs only in modality from the suggested nonverbal responses.

In other words, if the two stimulus objects are the same length, then the fact that one is displaced to the side does not alter the notion that the lengths are the same, and the child should respond as though the sticks are the same. If on the other hand the child is using the end points of the stimulus objects (or some other irrelevant dimension), then the conservation is not maintained, and the child should respond as if the stimuli are not similar, and should make the response associated with dissimilar stimuli.

The present study was designed to incorporate this analysis of the conservation problem, and to provide for the comparison of Piaget's clinical method with assessment made by operant techniques with regard to the child's ability to conserve length. It ought to be possible, if this functional analysis of the inclusion problem is accurate, to examine the development of conservation of length in children, whether or not they have developed verbal skills.

Statement of the Problem

In summary, the methodological weaknesses inherent in Piaget's "clinical" methodology have stimulated the present study. Specifically the weaknesses include the subject-experimenter interaction which provides for considerable opportunity for confusion and misunderstanding by both subject and experimenter. Also, the phrasing of questions and repeated questioning would appear to allow for response set formation by both experimenter and subject which would interfere with the assessment of the child's capabilities. Further, responses may be learned during repeated questioning and would increase the inaccuracy in assessment. Finally, it has been suggested that Piaget's studies either ignore verbal interaction as a source of bias or influence, or merely measure vocabulary growth.

In light of these problems developing from the use of clinical techniques, it would appear valuable to approach Piaget's constructs with a nonverbal technique which would minimize the contact and interaction between subject and experimenter. In this context the operant methods of Blough (1966) and Bijou and Baer (1966) have been discussed and shown to be at least logically appropriate for this type of investigation. Operant techniques appear to allow for nonverbal, behavioral assessment of the subject's cognitive development, but without being merely manipulative as other "nonverbal" investigations have been (e.g., Braine, 1959, 1962).

This, then, is the focus of the present study: a methodological comparison of Piaget's clinical data collection techniques with the techniques used by more behaviorally oriented researchers. In a broad sense it is an attempt to validate one of Piaget's major cognitive constructs using a methodology novel to traditional Piagetian research. In the narrow sense, the study has been designed to explore the adequacy of behavioral methods for measuring the cognitive development described by Piaget and thereby avoiding the possible problems in an interview situation.

Specifically the study has been designed to test the following hypotheses:

1. Behavioral techniques adequately distinguish between conservers and nonconservers as described by Piaget.

2. Behavioral methods and clinical methods independently yield similar results as to the conservation-nonconservation capabilities of subjects.

3. To the extent that the results of the two methods are not identical for a given subject (a) behavioral methods yield more conservers than do clinical methods, (b) behavioral methods yield conservers at a younger age than do clinical methods.

CHAPTER III

METHOD

Design

Each S was evaluated using both the clinical and the behavioral method of data collection. A counterbalanced procedure was employed. Half of the Ss were evaluated first by the clinical method, and then by the behavioral method. The remaining Ss were evaluated in the reverse sequence. Both evaluations were completed for each S during a single 45 minute period in order to minimize the confounding effects of learning and/or development.

Subjects

Ss were recruited by contacting the parents of all first grade children in three Grand Forks schools. The initial contact, made through a letter (Appendix A), explained the nature of the research and requested parental cooperation. Parents were asked to return a postcard, which had been included with the letter, indicating whether or not they would allow their child to participate. Those parents who indicated a willingness to participate were then contacted by telephone, and a specific appointment was made for each child.

Eighty-seven "initial contact" letters were mailed; 41 parents returned the postcards. Of the 41 returns, 37 indicated a willingness to participate. Four parents either were not willing to participate, or had moved from the area.

The sample of 37 included 17 males and 20 females. Four Ss from the original sample, one male and three females, were dropped when they failed to reach the behavioral training criterion within the allowed 120 trials. One additional male S was eliminated due to equipment failure during the behavioral portion of the evaluation. All Ss attended regular classes in Grand Forks, North Dakota, during the 1970-71 academic year. Fifteen Ss attended public schools; 17 Ss attended parochial schools.

The transition from nonconservation to conservation with regard to length occurs during the first half of the seventh year for approximately 50% of all children (Piaget et al., 1960). First grade children were used in the present study in order to assure that the S population would contain both conservers and nonconservers. The mean age for all Ss was 84.78 months; the standard deviation was 4.06 months. Age, sex and school data for individual Ss appears in Appendix B.

Although previous studies have failed to show sex differences, an effort was made to include approximately equal numbers of males and females in the sample.

Stimuli and Apparatus

Since two methods of assessment of conservation were involved, two different methods of presentation, and two forms of stimulus objects were used. For the clinical interview portion of the study, Ss were confronted with stimuli made of heavy construction paper; in the behavioral portion of the investigation two-dimensional pictoral representations of the stimulus objects were used.

Four sets of two identical "sticks" (two, three, four, and five inches long) were used in the clinical interview. All "sticks" were made of heavy construction paper and were one-half in. in width. The two and three in. sets were bright red in color; the four and five in. sets were dark blue. The order of presentation was constant for all Ss with the four in. set being presented first, followed by the two in., three in. and five in. sets. During the presentations, the first and third sets were visibly transformed (displaced) as the child watched; the second and fourth sets were transformed behind a screen and the child viewed only the beginning and end states.

In the behavioral portion of the study colored slides were projected on a milk glass screen located on the front surface of the apparatus described below. Slides, all of which employed blue stimuli on a white background, pictured various combinations of short (2 in.) and long (4 in.) "sticks." The short stick appeared both above and below the long stick. When a short and a long stick were paired all three spatial positions (left edges coincidental, right edges coincidental, and short stick centered along the long stick) were presented. Other slides presented two long or two short sticks in alignment. The order of presentation for all stimuli appears in Appendix C.

The apparatus consisted of the rectangular box-like arrangement which is shown in Figure 1. It was 24 in. long, 14 in. wide and 18 in. high, constructed of plywood and painted dark gray to increase the contrast between the stimulus displays and the apparatus itself.

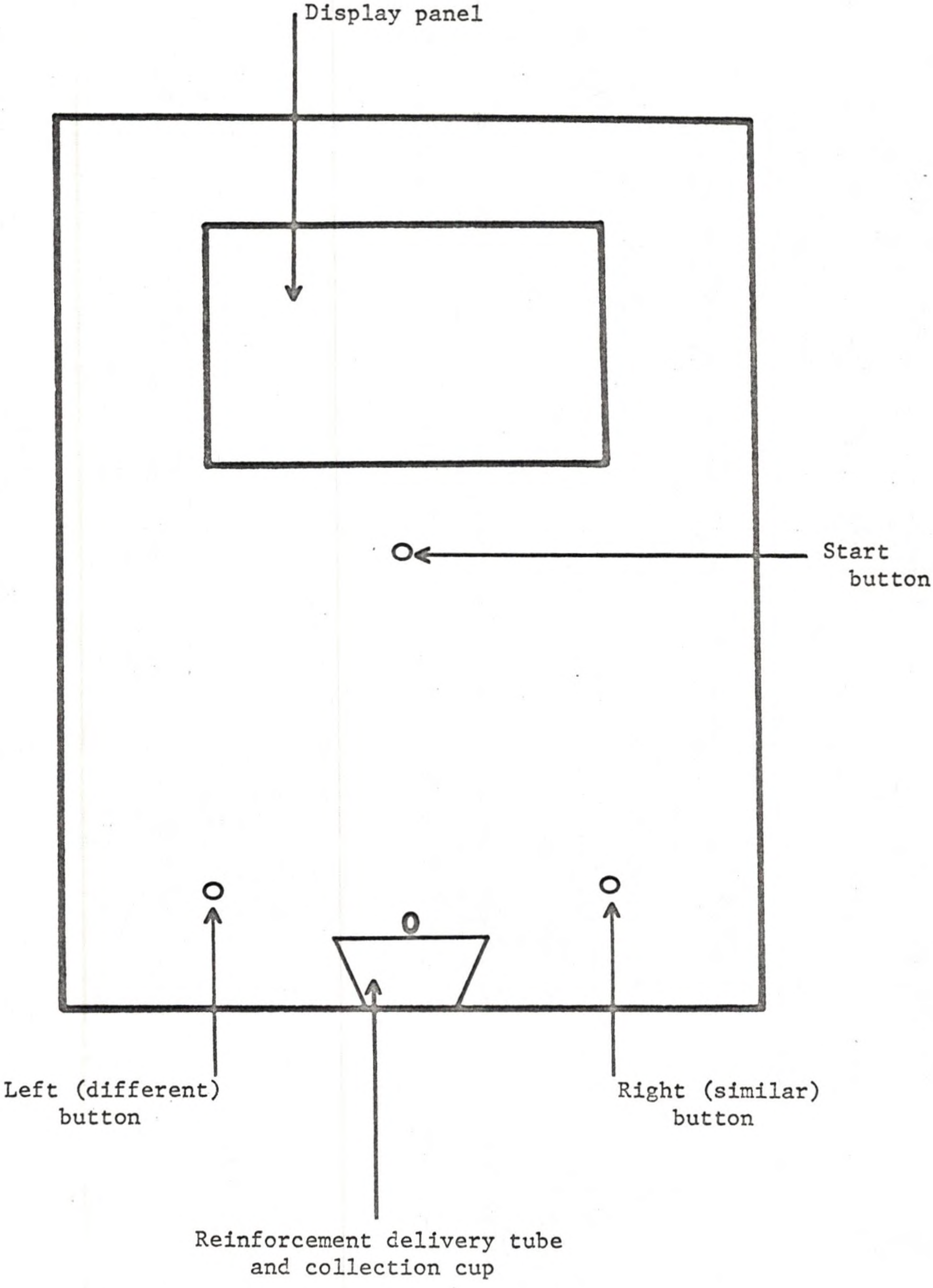

Fig. 1.--Front view of the behavioral apparatus.

Basically the apparatus consisted of a milkglass display panel located in the upper half of the front portion of the box. The display panel was illuminated and the stimulus objects (slides) were presented by means of a Kodak Carousel 800 slide projector. The apparatus was designed so that S was required to make a response (i.e., press a "start" button located below the display panel) to activate the slide projector. This was done to increase the probability of S attending to the visual display, and to make relevant stimulus dimensions as obvious as possible.

In the lower half of the front of the box were two push-type buttons which provided for the responses by Ss. One button (the right side) was "correct" for stimuli of the same length; the other button (the left side) was "correct" for stimuli of different lengths. Ss were not informed which button was correct for which stimuli.

Between the two push buttons a short segment of transparent plastic tubing led into a plastic cup for collecting reinforcements. Ss were encouraged to collect reinforcements whenever they wished, and were provided with a small dish so that they did not have to hold the reinforcements in their hands. Reinforcements were small, round, sugar-coated candies (Big Alberts) awarded one at a time for all correct responses, both similar and different.[1] Incorrect responses were not reinforced.

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[1]All Ss were checked for the presence of diabetes. The parents of one S, number 6, requested that no candy be given to their daughter. The request was made for personal rather than medical reasons. In keeping with this request, S 6 was verbally reinforced for correct responses during the behavioral portion of the study. Reinforcers included "Good," "Fine," and "That's right." There were no significant differences between responses of S 6 and those of Ss reinforced with candy.

Procedure

Ss were individually evaluated in both the clinical and the behavioral portion of the study. Ss were taken to a small room equipped with a table, several chairs and the apparatus described previously. Upon entering the experimental room, E and S spent several minutes talking in an effort to achieve rapport. The equipment, appropriate to the particular condition being presented to the child was pointed out. In the behavioral condition the equipment was demonstrated as explained below. All stimuli were concealed until the appropriate time of presentation. In both portions of the study S sat across the table from E with the materials in between them.

Clinical Procedure

As in the standard Piagetian conservation problem, Ss were confronted with a set of stimuli and then questioned about the relative length of the stimuli. An open, exploratory method of questioning was used, but standard questions were asked of all Ss, and the order of questioning was held constant. E had a copy of the questioning procedure (Appendix D), which was followed as exactly as possible. The interview was conducted in a conversational manner, with E directing the child's thinking only when he wandered too far from the experimental task.

In order to determine the reliability of judgements, all interviews were tape recorded. This also served to reduce the record keeping by E during the interview. Recorded interviews were played back at a later time, and an independent judge rated the child's conservation abilities. The judge was familiar with Piaget's theory and methodology.

He had no knowledge of the author's ratings for any S, and was naive with regard to S's age.

Three distinct problems were posed with each set of stimulu:

a. spontaneous conservation

b. hypothetical conservation

c. conflict conservation

In the spontaneous conservation section, Ss were asked whether the stimuli were the same length or different lengths following the transformation. He was then asked to justify his response (e.g., "How do you know that?").

In the second phase the child was asked to imagine that the sticks were returned to their original position (i.e., parallel end points), and then to make a judgement as to their relative lengths. Again, each S was asked to justify his response.

In the third section the child was told that another child had given a response contradictory to that which S had given. The child was then asked what he thought.

The following criteria were used to distinguish conservers from nonconservers for each set of stimuli:

(1) Ss who conserved spontaneously and answered and justified answers to all additional problems were considered conservers.

(2) Ss making any other response, or combination of responses, were considered to be nonconservers. [It is recognized that some Ss placed in this category on the basis of the above criteria may be in the transitional phase between

conservation and nonconservation (Substage IIB), but it is felt such Ss are best considered as nonconservers].

Ss were required to make conservation responses on at least three of the four sets of stimuli in order to be considered conservers in the clinical method. Ss making fewer such responses were considered to be nonconservers.

Behavioral Procedure

Prior to the behavioral assessment of conservation, Ss were trained to make appropriate nonverbal responses for stimuli of similar and different lengths. Each S was told that one button was "correct" on some occasions, and that the other button was "correct" at other times. Ss were told that they could be correct every time, and consequently receive a candy, if they would pay close attention to the stimuli. Actual instructions appear in Appendix E.

Training trials consisted of sets of stimuli obviously similar or obviously different in length. The purpose of these trials was to associate the correct nonverbal operant with the appropriate stimulus dimensions. Ss were trained until they reached a criterion of nine correct responses out of ten trials. The four Ss who did not reach criterion within 120 trials were dropped from the sample.

Following acquisition of the training task, Ss were exposed to 24 additional stimuli. Sixteen were of the type already described; 8 of the slides were designated as critical or test trials. On these slides one element of the set was displaced (transformed) to the right or left approximately one-third of its length. Test trials appeared in a pre-determined random order based on a table of random numbers.

Reinforcement for test trials was also pre-determined randomly from a table of random numbers. Random presentation and reinforcement was used to reduce the possibility of extinction during test trials. Appendix C contains a list of all trials indicating which were test trials, and which were reinforced.

CHAPTER IV

RESULTS

In the clinical portion of the investigation Ss were presented with four different sets of stimuli. Responses to each set of stimuli were judged for conservation (or nonconservation) by both the author and an independent judge. One hundred and twenty-eight (4 items/S x 32 Ss) separate judgements were made by each judge. (Judgements for individual Ss appear in Appendix F.) Agreement between the author and the judge was 96.88%. There was never more than one disagreement per S. Further, none of the disagreements were critical in classifying Ss as conservers or nonconservers as the agreement on that dichotomy was 100%.

In the behavioral portion of the study, eight test trials were presented to each S. Ss who responded on six or more of those trials by pushing the "same length" button (i.e., that button which had been associated with sticks of the same length through reinforcement) were considered conservers.

Decisions made on the basis of behavioral data were the same as decisions made on the basis of clinical data for 25 of 32 Ss (78.13%). Table 1 presents the 2 x 2 matrix resulting from this dual classification. Eleven Ss were identified as conservers by both clinical and behavioral methods, and 14 Ss were identified as nonconservers by both methods. Five Ss were identified as conservers

TABLE 1

IDENTIFICATION AND LOCATION OF SUBJECTS CLASSIFIED BY CLINICAL AND BEHAVIORAL METHODS

Clinical Method		Behavioral Method: Nonconservers	Behavioral Method: Conservers
	Conservers	N = 2 Ss 3, 19	N = 11 Ss 2, 5, 6, 7, 13, 17, 22, 23, 27, 28, 31
	Nonconservers	N = 14 Ss 1, 4, 9, 10, 15, 18, 20, 21, 24, 25, 26, 29, 30, 32	N = 5 Ss 8, 11, 12, 14, 16

by behavioral methods, but not by clinical, while two Ss were identified as conservers by clinical and not by behavioral methods.

A Chi Square (Siegel, 1956, pp. 104-110) was applied to the data in Table 1. The Chi Square (corrected for continuity) was significant beyond the .01 level ($\chi^2 = 8.29$, _df_ = 1) suggesting that the two methods are related.

A McNemar Test of Change (Siegel, 1956, pp. 63-67) was applied to determine the significance of the seven Ss who differed from one method to the other. The analysis was not significant ($\chi^2 = 1.28$, _df_ = 1), suggesting that the discrepancies between the two methods are not significantly different from chance.

In order to assess the effect of order of evaluation, the data were cast in terms of Ss receiving the clinical evaluation first and Ss receiving the behavioral evaluation first. Separate matrices were constructed for decisions based on clinical data and decisions based on behavioral data. Both matrices are presented in Table 2. Chi Squares, corrected for continuity, (Siegel, 1956, pp. 104-110) were applied to the data and neither Chi Square was significant.

TABLE 2

ORDER EFFECTS FOR CLINICAL AND BEHAVIORAL EVALUATIONS

	Method of Assessment			
	Clinical		Behavioral	
	Nonconserver	Conserver	Nonconserver	Conserver
Clinical Evaluation First	N = 10	N = 6	N = 10	N = 6
Behavioral Evaluation First	N = 9	N = 7	N = 6	N = 10

The number of presentations on which S made conserving responses provide a second basis for comparison of the two methods. These numbers have been termed "conservation scores." In the behavioral portion of the investigation conservation scores range from zero (indicating that S did not make any conserving responses) to a maximum of eight (indicating that S made a conserving response at every opportunity). In the clinical portion of the experiment, the number of conserving responses as determined by both the author and the independent judge were added together. The resultant scores also ranged from zero (no conservation responses) to eight (conservation response at every opportunity). Raw scores appear in Appendix F.

Conservation scores were analyzed using the Wilcoxon Matched-Pairs Signed-Ranks Test (Siegel, 1956, pp. 75-83). The Wilcoxon analysis is summarized in Table 3. The results are significant at the .05 level (two-tailed) suggesting that the conservation scores for the behavioral assessment method are significantly larger than the scores for the clinical assessment method. However, this result may be spurious since the probabilities for correct responses were different for the two methods. In the behavioral condition, S had a 50% chance of making a correct response by chance alone. In the clinical condition, S's probability of making a correct response by chance alone is not greater than 33%, and probably less, since more than one response was required.

In order to test this possibility a Cochran Q Test (Siegel, 1956, pp. 161-166) was applied to the categorical decisions (conserver vs. nonconserver) of the author, the independent judge, and the behavioral method. This analysis is summarized in Table 4. The $\underline{Q}$ value does not reach significance ($\underline{Q} = 2.57$, $\underline{df} = 2$) suggesting that the differences between clinical and behavioral methods in terms of presence or absence of conservation were no greater than chance.

In addition to analyses comparing behavioral and clinical data, analyses also were performed to assess other aspects of the investigation. To assess possible sex differences, male and female conservers and nonconservers were identified for both the clinical and the

TABLE 3

SUMMARY OF WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST ON CONSERVATION SCORES FOR CLINICAL AND BEHAVIORAL ASSESSMENTS

S	Clinical Conservation Score	Behavioral Conservation Score	Difference	Ranked Difference	Least Frequent Rank
1	3	3	0		
2	7	6	1	4.5	4.5
3	8	2	6	23.5	23.5
4	0	5	-5	-21	
5	8	7	1	4.5	4.5
6	8	8	0		
7	6	6	0		
8	0	8	-8	-27	
9	0	2	-2	-11.5	
10	0	3	-3	-15.5	
11	2	6	-4	-18	
12	0	6	-6	-23.5	
13	8	6	2	11.5	11.5
14	0	7	-7	-25.5	
15	0	4	-4	-18	
16	0	7	-7	-25.5	
17	8	6	2	11.5	11.5
18	0	3	-3	-15.5	
19	8	3	5	21	21
20	0	0	0		
21	0	1	-1	- 4.5	
22	8	7	1	4.5	4.5
23	8	7	1	4.5	4.5
24	3	2	1	4.5	4.5
25	0	2	-2	-11.5	
26	0	1	-1	- 4.5	
27	7	6	1	4.5	4.5
28	6	6	0		
29	0	2	-2	-11.5	
30	0	4	-4	-18	
31	8	6	2	11.5	11.5
32	0	5	-5	-21	
				T =	106

N = 27 Z = 1.96*

*Significant at .05 level

TABLE 4

COCHRAN Q TEST ON CONSERVATION-NONCONSERVATION DECISIONS FOR TWO JUDGES AND BEHAVIORAL DATA

Subject Number	Judge 1	Judge 2	Behavioral Decision	L_i	L_i^2
1	0	0	0		
2	1	1	1	3	9
3	1	1	0	2	4
4	0	0	0		
5	1	1	1	3	9
6	1	1	1	3	9
7	1	1	1	3	9
8	0	0	1	1	1
9	0	0	0		
10	0	0	0		
11	0	0	1	1	1
12	0	0	1	1	1
13	1	1	1	3	9
14	0	0	1	1	1
15	0	0	0		
16	0	0	1	1	1
17	1	1	1	3	9
18	0	0	0		
19	1	1	0	2	4
20	0	0	0		
21	0	0	0		
22	1	1	1	3	9
23	1	1	1	3	9
24	0	0	0		
25	0	0	0		
26	0	0	0		
27	1	1	1	3	9
28	1	1	1	3	9
29	0	0	0		
30	0	0	0		
31	1	1	1	3	9
32	0	0	0		
	$G_1 = 13$	$G_2 = 13$	$G_3 = 16$	$\Sigma L_i=42$	$\Sigma L_i^2=112$

Q = 2.57 *df* = 2 p >.20

behavioral method. Table 5 summarizes this data. A Chi Square corrected for continuity (Siegel, 1956, pp. 104-110) was used to test the hypothesis of no sex differences. Neither the Chi Square for the clinical data (χ^2 = .183, df = 1), nor for the behavioral data (χ^2 = 2.01, df = 1) was significant, suggesting that sex differences were not significantly different from chance differences.

TABLE 5

IDENTIFICATION AND LOCATION OF SUBJECTS BY SEX AND METHOD OF CONSERVATION ASSESSMENT

Sex	Method of Assessment			
	Clinical		Behavioral	
	Nonconserver	Conserver	Nonconserver	Conserver
	N = 10	N = 5	N = 10	N = 5
Male	Ss 1, 4, 9, 10, 12, 20, 24, 25, 29, 32	Ss 3, 5, 7, 13, 28	Ss 1, 3, 4, 9, 10, 20, 24, 25, 29, 32	Ss 5, 7, 12, 13, 28
	N = 9	N = 8	N = 6	N = 11
Female	Ss 8, 11, 14 15, 16, 18, 21, 26, 30	Ss 2, 6, 17, 19, 22, 23, 27, 31	Ss 15, 18, 19, 21, 26, 30	Ss 2, 6, 8, 11, 14, 16, 17, 22, 23, 27, 31

In the clinical interview, it will be recalled, the first and third stimulus presentations were visibly transformed, while the second and fourth transformations were carried out behind a screen. In order to assess any differences between the two conditions, the conservation scores of both the author and the judge were combined for trials one and three, and also for trials two and four. A Wilcoxon Matched-Pairs

Signed-Ranks Test (Siegel, 1956, pp. 75-83) was used to test the hypothesis. The analysis, summarized in Table 6, does not reach significance,

TABLE 6

SUMMARY OF WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST ON CONSERVATION SCORES FOR VISIBLE AND INVISIBLE TRANSFORMATIONS

S	Visible Transformation Conservation Score	Invisible Transformation Conservation Score	Difference	Ranked Difference	Least Frequent Rank
1	2	1	1	2.5	2.5
2	3	4	-1	-2.5	
3	4	4	0		
4	0	0	0		
5	4	4	0		
6	4	4	0		
7	2	4	-2	-6	
8	0	0	0		
9	0	0	0		
10	0	0	0		
11	2	0	2	6	6
12	0	0	0		
13	4	4	0		
14	0	0	0		
15	0	0	0		
16	0	0	0		
17	4	4	0		
18	0	0	0		
19	4	4	0		
20	0	0	0		
21	0	0	0		
22	4	4	0		
23	4	4	0	2.5	2.5
24	2	1	1		
25	0	0	0	-2.5	
26	0	0	0	-6	
27	3	4	-1		
28	2	4	-2		
29	0	0	0		
30	0	0	0		
31	4	4	0		
32	0	0	0		
					T = 11
	N = 7	p >.05			

suggesting that the difference in conservation scores between those presentations where the transformations are visible and those presentations where the transformations are invisible is not significantly greater than chance.

Analyses were also performed on the behavioral training data. The means and standard deviations of ages for Ss classified as conservers and non-conservers appear in Table 7. A two-way analysis of variance for unequal cell frequencies (Winer, 1962, pp. 241-244) was used, a summary of which appears in Table 8. None of the F ratios reached significance.

TABLE 7

MEANS AND STANDARD DEVIATIONS FOR AGE OF SUBJECTS CLASSIFIED AS CONSERVERS AND NONCONSERVERS BY CLINICAL AND BEHAVIORAL METHODS

		Behavioral Method	
		Conservers	Nonconservers
Clinical Method	Conservers	Mean = 84.63 months SD = 3.96	Mean = 84.00 months SD = 4.00
	Nonconservers	Mean = 83.60 months SD = 3.01	Mean = 85.42 months SD = 4.56

TABLE 8

ANALYSIS OF VARIANCE OF AGES OF SUBJECTS CLASSIFIED AS CONSERVERS AND NONCONSERVERS BY CLINICAL AND BEHAVIORAL METHODS

Source of Variation	df	MS	F	P
Clinical Method	1	.18	.01	NS
Behavioral Method	1	1.63	.09	NS
A x B	1	6.98	.38	NS
Within cells	28	18.05		

The means and standard deviations for number of trials to reach criterion appear in Table 9. A two-way analysis of variance for unequal

TABLE 9

MEANS AND STANDARD DEVIATIONS OF RAW AND TRANSFORMED TRIALS TO CRITERION DATA FOR SUBJECTS CLASSIFIED AS CONSERVERS AND NONCONSERVERS BY CLINICAL AND BEHAVIORAL METHODS

Clinical Method	Behavioral Method: Nonconservers	Behavioral Method: Conservers
Conservers	Mean = 37.50 Log mean = 1.477 SD = 22.49 Log SD = .30	Mean = 69.36 Log mean = 1.643 SD = 36.16 Log SD = .34
Nonconservers	Mean = 71.07 Log mean = 1.761 SD = 39.99 Log SD = .31	Mean = 43.20 Log mean = 1.500 SD = 36.50 Log SD = .33

cell frequencies (Winer, 1962, pp. 241-244) was used to test this data. In order to normalize the positively skewed distribution a logarithmic transformation was made prior to analysis (Winer, 1962, p. 221). The analysis of the transformed data is summarized in Table 10. None of the *F* ratios reached significance.

TABLE 10

ANALYSIS OF VARIANCE OF NUMBER OF TRIALS TO CRITERION FOR SUBJECTS CLASSIFIED AS CONSERVERS AND NONCONSERVERS BY CLINICAL AND BEHAVIORAL METHODS

Source of Variation	df	MS	F	P
Clinical Method	1	.279	2.28	NS
Behavioral Method	1	.139	1.143	NS
A x B	1	.205	1.68	NS
Within cells	28	.122		

CHAPTER V

DISCUSSION

The primary hypotheses of this investigation have been supported. Data obtained in a manner using minimal verbal interaction (designated as the behavioral method) is sufficient to distinguish between conservers and nonconservers. Furthermore, the distinctions obtained using the behavioral method are similar to those made on the basis of data obtained in the traditional interview situation.

The first hypothesis predicted that the behavioral method would distinguish between conservers and nonconservers. Data presented in Table 1 and the subsequent analyses of these data support this hypothesis. The behavioral method developed in this investigation is a valid means of assessing the conservation level of children.

Inspection of Table 1 shows that when Ss are divided on a conservation-nonconservation dichotomy on the basis of behavioral data there are more conservers than when the distinction is made on the basis of clinical data. Sixteen Ss are identified as conservers from behavioral data; on the basis of clinical data 13 Ss were identified as conservers.

The second hypothesis predicted that the decisions made by clinical and behavioral methods would be similar for any particular S. The data also support this hypothesis. Not only does the behavioral method distinguish between conservers and nonconservers, but it yields results which are very similar to results from a clinical interview. In terms of gross classifications (i.e., conservation versus nonconservation), the decisions made on the basis of the behavioral data are essentially the same as those made on the basis of the interview for any particular S. Seventy-eight percent of the decisions were the same. The significant Chi Square on the data in Table 1 ($\chi^2 = 8.29$, $df = 1$) suggests that the two measures are related. In other words, decisions based on behavior are in some way related to clinical decisions.

Piaget has suggested that the clinical interview is the only method which is sufficiently flexible to assess such concepts as conservation (1929). Present results suggest that a behavioral method, although not as flexible as the clinical method, yields similar results in assessing conservation of length.

At the present time the behavioral method as applied to the conservation problem is very crude. There is little doubt that a considerable amount of information is lost, especially as compared to the clinical method. For example, as the conservation problem has been analyzed, and as the instrumentation has been developed, it is not possible to identify Ss in a transitional phase of conservation (Substage IIB). Nor is it possible to determine which of the many possible types of nonconservation response is being given. Refinements in the behavioral technique are necessary for more precise measurement of conservation. Finer discriminations do appear possible.

In spite of the apparent loss of information, the behavioral method appears to have a number of advantages over the clinical method. First, the behavioral method eliminates the need for the child to understand what is being requested of him (in terms that can be verbalized), once the apparatus has been explained and demonstrated. The child's behavior is not dependent upon his understanding of the examiner's instructions, but on his reinforcement history in the examination situation. It should be noted that the discriminatory operant (left or right button pushing) could be developed in the _absence of any verbal instruction_, although considerable time would be required. Therefore the behavioral method has considerable application to nonverbal populations (animals, very young children) or populations with limited verbal ability (young children, retarded, emotionally handicapped, etc.).

Second, the behavioral method eliminates the necessity for S to understand such terms as "longer," "same," and "equal." Since the training procedure shapes an association between a button and stimuli of the same length, and a second association between a different button and stimuli of different length, there is no need for verbal labels. The behavioral method permits the child to attend to variables (or elements of the situation) and to respond to those variables without being able to name them. Piaget's clinical interview requires that the examiner and the child have the same reference system when speaking about the stimuli. Even when the examiner adopts the vocabulary of the child (e.g., referring to "roads" instead of sticks; using "further" to mean longer, etc.) it is essential that each understand the terminology of the other. Thus the behavioral method allows for assessment of abilities which have been mastered intellectually, but which children are not capable of discussing verbally.

The behavioral method appears to have a third advantage in that the opportunities for E to cue or reinforce S inadvertently are reduced to a minimum. Thus the behavioral method has the capacity to be much more precise than the clinical method. It should be noted that some of the children did not realize that E was delivering the reinforcements during the behavioral portion of the study. Most commented that they enjoyed the machine because it "gave me candy."

While the classifications by the two methods are similar, they are not identical as is evident from Table 1. The insignificant McNemar Test of Change ($\chi^2 = 1.28$, $df = 1$) suggests that discrepancies between the two methods are not significantly different than chance. The two methods are not perfectly reliable for any given S, but errors in either direction do not differ significantly from chance fluctuations.

Several authors (Braine, 1962; Hall & Kingsley, 1968) have suggested that conservation is largely dependent upon phrasing of the interview by the examiner, and/or behavioral cues from the examiner. Behavioral data, which minimized both of these biases, indicate that conservation does exist independently of experimenter influences. In examining the similarity of decisions based on clinical and behavioral data, it is reasonable to conclude that conservation is not an artifact of the examiner's behavior.

The significant relationship between the two methods of assessment also serves to validate Piaget's description of conservation development (Piaget, Inhelder & Szeminska, 1960). The fact that conservers can be distinguished from nonconservers using behavioral methods lends support to the validity of the construct of conservation. It is not a circumscribed behavior which appears only in an interview. It is reasonable to conclude that conservation is not an artifact of the clinical method of assessment.

While it is possible that some biasing was present in the clinical interview portion of this investigation, the data suggest the contrary. For conservation-nonconservation decisions the interjudge reliability was 100%. Even when the individual responses are considered for each of the four items, reliability was better than 96%. The data presented in Table 3 also serve as a check on the reliability of the judgements made by the author and the independent judge. Since the results were nonsignificant ($Q = 2.57$, $df = 2$), it is suggested that differences between the judges are not greater than chance. If bias was being introduced, it was done in such a manner that the second judge, listening only to the tape-recorded interview, was unaware of the bias, and made decisions similar to the author.

The reliability between methods (0.78) also suggests that any bias was probably nonsystematic, influencing both methods to some degree. The analysis summarized in Table 4 also supports this notion.

A number of investigators (Furth, 1964, 1966, 1969; Piaget & Inhelder, 1969; Sinclair-de-Zwart, 1969) have suggested that cognitive development is independent of, and may precede equivalent language development. If this were the case, behavioral methods, in which the use of language has been minimized, might be expected to yield more conservers and at a younger age. Specifically, behavioral methods might be expected to locate those children capable of conservation on an intellectual level, but incapable of verbal justification of conservation.

The third hypothesis, which was developed to assess the influence of language along the lines discussed above, was only partially supported. Results suggest that the behavioral method yields more conservers and identifies more conserving responses than clinical methods, although the level of measurement appears to be important. Results do not support the predicted age difference.

The Wilcoxon Matched-Pairs Signed-Ranks Test summarized in Table 2 supports the notion that more conservation responses are identified by behavioral methods than by clinical methods. Visual inspection of Table 1 shows that more conservers are identified by behavioral methods than by clinical methods (16 as compared to 13). Thus, behavioral methods do yield more conservers, and identify more conserving responses than do clinical methods.

Since it appeared that guessing could have influenced the data in the behavioral condition disproportionately, a Cochran Q Test was applied to the data. This analysis (Table 3) produced a nonsignificant Q ($Q = 2.57$, $df = 2$), suggesting that the superiority of the behavioral method over the clinical method is rather weak, occurring only at the ordinal level when conservation scores are used. One method of resolving this issue would be to allow for more choices in the behavioral condition. This might be accomplished by providing buttons for "same," "different," and "undecided." A second method might use a comparison between a test stimulus and a target or sample stimulus, and provide choices of "longer," "shorter," and "equal." Obviously, more research is required in the application of operant techniques to the assessment of conservation.

The second part of the third hypothesis predicted that behavioral techniques would identify conservers at a younger age than would clinical methods. This hypothesis was developed as a logical extension of the prediction that removal of language requirements would increase the number of conservation responses. If Ss fail to conserve because their responses are unacceptable, or because they are unable to express their convictions, even when they are capable of conservation intellectually, then they should be younger than Ss responding in a more acceptable manner. The data presented in Tables 6 and 7 suggest that there are no significant differences in age between conservers and nonconservers for either of the two methods. Thus this portion of the third hypothesis has not been supported.

These findings provide some indirect support for Piaget's clinical methodology. Considering the suggestion that intellectual development may precede language development, verbal and nonverbal methods would be expected to yield different results. The results cited above suggest that the differences between a verbal method (clinical interview) and a nonverbal method (behavioral) are not significant. Present results fail to support the contention that the verbal interview may mask intellectual conservation.

Several factors appear to contribute to the failure to support this hypothesis. First, the range of ages of the Ss in this investigation may have been too small to detect any significant differences in age. Piaget et al. (1960) report that 50% of children tested achieve conservation of length between seven and seven and one-half. Since the average age of all Ss in this investigation was seven years, it is likely that many were on the verge of conservation, if they were not already conservers. In other words, it is likely that many of the Ss were transitional (Substage IIB). As such their responses would tend to be inconsistent and possibly contribute to the discrepancies between behavioral and clinical decisions.

Second, all of the Ss were attending first grade at the time the study was conducted. Consequently, all were receiving considerable verbal stimulation and all were participating in mathematics activities, which may have involved lessons in "same" and "different." In short the immediate environment, especially as defined by the classroom, was rather similar for all Ss.

It appears that a greater range of ages would alleviate both of these problems. Children ranging in age from four through eight, for example, would eliminate the probability that most Ss are either conservers or transitional conservers. Also, it would reduce the similarity of environmental experience, since the youngest children would not be receiving the same sorts of instruction as the oldest children, if indeed they would be receiving any at all.

In sum, while the age portion of the third hypothesis has not been supported, the negative findings appear related to the population, rather than the behavioral method as such. Further research is required in this area to improve the behavioral methodology.

A number of studies (Sawda & Nelson, 1968b; Olson & Lorimer, 1969; Sullivan, 1969) have focused on the transformation in the conservation task. The results of these studies are not clear as to the importance of the transformation. Since the transformations in the behavioral portion of the investigation were invisible, data on this factor was obtained during the clinical interview to serve as a control.

The data analyzed in Table 5 suggest that there was no significant difference in conservation score for those trials where the transformation was visible compared to those where the transformation was invisible (i.e., carried out behind a screen). This suggests that the transformation, or at least its visibility, is not a critical variable in the conservation of length. However, further research in this area is required to investigate such variables as the amount of displacement, the proximity of the stimuli, the orientation of the stimuli, and left-right displacement as compared to a broken (undulating) line.

The analysis of variance on the number of trials to criterion in the behavioral training session is also of interest in the development of the behavior technique. These data, presented in Tables 8 and 9, suggest that conservers and nonconservers do not differ significantly in number of trials required to learn the task.

Piaget (Piaget, Inhelder and Szeminska, 1960) suggests that conservation requires the recognition of "locations" or "sites" as independent of the object occupying those locations. He concludes

> Thus, there can be no conservation of length . . . unless there is a reference system which provides a common medium for all objects . . . and this in turn implies that there must be a composition as between objects and their parts, and empty sites (p. 103).

It appears logical that Ss who are conservers, and who have learned the importance of the "sites," should attend to them more readily than Ss who have not yet recognized "sites." Present data do not support this thinking.

There seem to be two possible explanations. First, it is possible that because of the restricted sample there are no significant differences in the attention given to sites and locations. It is possible that the Ss all were very close to being conservers and perceived the sites as important, but some responded inconsistently (being in the transitional phase) and were classified as nonconservers.

The second possibility is that the importance of sites has been overemphasized as a factor in the development of conservation. Since there are no significant differences in number of trials required to learn the task, and since some Ss were classified as conservers, and some as nonconservers, it is possible that the perception of locations is not a valid criterion for distinguishing between conservers and nonconservers. Additional research on the variables involved might shed some light on the problem. Refinements in the behavioral technique might facilitate a conserver-nonconserver discrimination based on invariant sites and independent of the objects which occupy those sites.

Previous studies have failed to find sex differences in conservation of length. Analysis of the data supports these findings. There were no significant differences between conservers and nonconservers on the basis of sex for either clinical or behavioral assessment techniques.

In summary, on the basis of the results of the present study, the behavioral method is a valid technique for the assessment of conservation of length. Although the behavioral method loses much personal information, it seems to have several methodological advantages over clinical methods. It seems to be applicable to nonverbal populations and populations with limited verbal ability. Behavioral methods minimize the opportunity for the examiner to bias or cue S. Consierable research is required on specific aspects of the behavioral method in order to improve the precision in identifying transitional conservers, and to assess the effects of a number of stimulus variables on conservation.

APPENDIX A

Mr. and Mrs. John Doe
1234 Anycity Street
Grand Forks, North Dakota 58201

Dear Mr. and Mrs. Doe

During the past year I have been involved in a series of studies on the development of school age children. I am particularly interested in discovering what young children do with various kinds of objects and how they react to various situations. I hope that these studies will enable us to understand more about young children and suggest ways in which we might improve our educational system.

In order to carry out these studies, I need the cooperation of parents who are willing to allow their children to participate. At the present time I am working with 6 - 7 year old (first grade) children. I am writing to ask if you would be kind enough to let me include your child in my current study.

So that no child will miss regular classroom instruction, all aspects of my study will be completed during non-school hours. The research requires one short session of approximately 45 minutes. These sessions will be scheduled after school in the afternoon, and on weekends. Should you consent to your child's participation, I would be happy to schedule a session that would be convenient for both you and your child. The sessions will be conducted at my office in Corwin Hall on the University Campus.

For your convenience, a self-addressed post card is enclosed. Kindly indicate on the card whether or not you agree that your child participate in this study and return the card at your earliest convenience. If you indicate that you would allow your child to participate, would you also include your phone number, and I will phone you within the next couple of weeks to arrange a specific time and answer any questions you may have concerning the study. If it would be helpful, I would be glad to provide your child with a ride both to and from the University Campus.

Because my research is designed to help in understanding how all children behave, I shall not be evaluating your child as an individual and will not have scores for any single child. Rather, I shall be considering first grade children in general. I will be happy to send you a summary of the results of the study when it is completed. I would like to thank you in advance for your cooperation in this study.

Sincerely,

Richard E. Harder
Instructor

APPENDIX B

DEMOGRAPHIC INFORMATION FOR ALL SUBJECTS

Subject Number	Age (months)	Assessment order	Sex	School
1	88	B-C	male	parochial
2	78	B-C	female	parochial
3	88	C-B	male	parochial
4	87	C-B	male	parochial
5	91	C-B	male	parochial
6	85	C-B	female	parochial
7	85	C-B	male	parochial
8	80	B-C	female	parochial
9	90	C-B	male	parochial
10	90	C-B	male	parochial
11	88	B-C	female	parochial
12	86	C-B	male	parochial
13	89	B-C	male	parochial
14	81	B-C	female	parochial
15	85	B-C	female	parochial
16	83	B-C	female	parochial
17	83	B-C	female	public
18	82	C-B	female	parochial
19	80	B-C	female	public
20	91	C-B	male	public
21	80	C-B	female	public
22	85	B-C	female	public
23	80	B-C	female	public
24	88	B-C	male	public
25	82	C-B	male	public
26	82	C-B	female	public
27	89	B-C	female	public
28	85	C-B	male	public
29	80	B-C	male	public
30	92	C-B	female	public
31	81	C-B	female	public
32	79	B-C	male	public

APPENDIX C

DESCRIPTION AND ORDER OF PRESENTATION OF BEHAVIORAL STIMULI

Slide Number	Length and orientation	Relationship of extremities (left, right, centered)
1.	long over long	centered
2.	long over short	right parallel
3.	short over short	centered
4.	short over long	right parallel
5.	long over short	centered
6.	short over long	left parallel
7.	short over long	centered
8.	long over short	left parallel
9.	long over short	right parallel
10.	short over short	centered
11.	short over long	right parallel
12.	long over short	centered
13.	short over long	left parallel
14.	short over long	centered
15.	long over short	left parallel
16.	long over long	centered
17.	long over short	left parallel
18.	short over long	centered
19.	short over long	left parallel
20.	long over short	centered
21.	short over long	right parallel
22.	short over short	centered
23.	long over short	right parallel
24.	long over long	centered
25.	short over long	centered
26.	short over long	left parallel
27.	long over short	centered
28.	short over long	right parallel
29.	short over short	centered
30.	long over short	right parallel
31.	long over long	centered
32.	long over short	left parallel
33.	short over long	left parallel
34.	short over long	centered
35.	long over short	left parallel
36.	long over long	centered
37.	long over short	right parallel
38.	short over short	centered
39.	long over short	right parallel
40.	long over short	centered

[This series was repeated until the S reached criterion (nine correct responses in the last ten trials) or a maximum of three times (120 presentations)].

Slide Number	Length and orientation	Relationship of extremities (left, right, centered)
41.	short over long	centered
42.	long over long*	displaced left
43.	short over long	left parallel
44.	short over long	right parallel
45.	short over long	centered
46.	short over short*	displaced right
47.	short over short	centered
48.	long over long*	displaced right
49.	long over short	left parallel
50.	long over short	right parallel
51.	short over short*	displaced left
52.	long over long	centered
53.	long over short	centered
54.	long over long*	displaced right
55.	short over long	right parallel
56.	short over short	centered
57.	long over long*	displaced right
58.	long over short	right parallel
59.	long over long	centered
60.	short over short*	displaced left
61.	long over short	left parallel
62.	short over long	centered
63.	short over short*	displaced right
64.	short over long	left parallel

Note.--An asterisk (*) denotes a test trial. Test trials 42, 51, 57, and 60 were reinforced; test trials 46, 48, 54, and 63 were not reinforced.

CLINICAL INTERVIEW PROCEDURE

1. Conservation of Equality of Length

Materials: set of two identical sticks - 3 1/2 inches long

Procedure: before the session, the segments are lined up parallel to each other and about one-half inch apart

S

E

E: Look at these____(name of child)______. Is this stick (pointing to stick nearest the E) longer, or is this stick (pointing to stick farthest from E) longer, or are both the same?

If the child answers correctly -

E: That's very good.

If the child answers incorrectly, hesitates, or says, "I'm not sure." -

E: Is there anything you can do to find out? Put this stick (near) on top of this (far) one.

E: (If child does so, E replaces sticks in original position). Is this stick longer (near), or is this stick (far) longer, or are both the same?

Regardless of answer -

E: That's very good.

A. Transformation

Materials: same as in above example

Procedure: the experimenter (after first replacing the sticks in their original position, if necessary) pushes the stick nearest the E to the left (E's left) approximately one-half the length of the stick with the child watching the transformation.

S

E

E: Look at these____(child)_____. Is this stick (near) longer, or is this stick (far) longer, or are both the same?

If child responds with an answer -

E: How do you know that?

If child hesitates, or indicates he is not sure-

E: If you put these sticks back as they were before I moved them, would this stick (near) be longer, or would this stick (far) be longer, or would both be the same?

E: How do you know?

E: Another child told me -

1. this stick (near) and this stick (far) are not the same (if child identifies the sticks as the same)

   or,

2. this stick (near) and this stick (far) are the same (if child indicates that the sticks are not the same)

What do you think?

(The entire procedure was repeated four times, each time with a different set of two equal stimuli. The transformations in the second and fourth presentations were carried out behind a screen so that the S saw only the static figures.)

INSTRUCTIONS FOR BEHAVIORAL APPARATUS

Okay, (name of child), now we will be working with this machine (pointing to the apparatus). This button (pointing to the "start" button) starts the machine; push it and see what happens. Look, there is a picture on this little screen (pointing to the display panel). This button (pointing to the button on S's right) and this button (pointing to the button on S's left) turn the machine off. Push one of them and se what happens. Now, (name of child) turn the machine on again; see, there is a new picture. Now push the other button which turns the machine off. That's very good.

(Name of child), sometimes this is the correct button (pointing to the right hand button), and sometimes this is the correct button (pointing to the left hand button). If you watch the pictures (pointing to the display panel) very carefully you can learn whether to push this button (left) or this button (right). When you push the correct button a piece of candy will drop into this little box (pointing to the reinforcement collection cup). Those candies are for you.

Let's practice again. Push the button to start the machine. Remember that sometimes this button (left) will be correct, and sometimes this button (right) will be correct. And remember that if you push the correct button you will get a piece of candy. Now turn the machine off. Very good. No candy this time because this is only practice. Start the machine again; now push the other button to turn it off. Remember to watch the pictures very carefully, and try to get a piece of candy every time. You can do it. Okay, (name of child) start the machine.

(On occasion it was necessary to encourage the child to continue after he had completed the first trial. This was accomplished in all instances by asking the child to "try the next one.")

APPENDIX F

TABLE 11

RAW DATA FOR ALL SUBJECTS

Subject Number	Judge	Clinical Stimulus Number 1	2	3	4	Number of Clinical Conservation Responses	Clinical Conservation Score	Behavioral Conservation Score
1	A[1]	N[3]	N	C[4]	N	1	3	3
	I[2]	N	C	C	N	2		
2	A	C	C	C	C	4	7	6
	I	N	C	C	C	3		
3	A	C	C	C	C	4	8	2
	I	C	C	C	C	4		
4	A	N	N	N	N	0	0	5
	I	N	N	N	N	0		
5	A	C	C	C	C	4	8	7
	I	C	C	C	C	4		
6	A	C	C	C	C	4	8	8
	I	C	C	C	C	4		
7	A	N	C	C	C	3	6	0
	I	N	C	C	C	3		
8	A	N	N	N	N	0	0	8
	I	N	N	N	N	0		
9	A	N	N	N	N	0	0	2
	I	N	N	N	N	0		
10	A	N	N	N	N	0	0	3
	I	N	N	N	N	0		
11	A	C	N	N	N	1	2	6
	I	C	N	N	N	1		
12	A	N	N	N	N	0	0	6
	I	N	N	N	N	0		
13	A	C	C	C	C	4	8	6
	I	C	C	C	C	4		
14	A	N	N	N	N	0	0	7
	I	N	N	N	N	0		

TABLE 11--Continued

Subject Number	Judge	Clinical Stimulus Number 1	2	3	4	Number of Clinical Conservation Responses	Clinical Conservation Score	Behavioral Conservation Score
15	A	N	N	N	N	0	0	4
	I	N	N	N	N	0		
16	A	N	N	N	N	0	0	7
	I	N	N	N	N	0		
17	A	C	C	C	C	4	8	6
	I	C	C	C	C	4		
18	A	N	N	N	N	0	0	3
	I	N	N	N	N	0		
19	A	C	C	C	C	4	8	3
	I	C	C	C	C	4		
20	A	N	N	N	N	0	0	0
	I	N	N	N	N	0		
21	A	N	N	N	N	0	0	1
	I	N	N	N	N	0		
22	A	C	C	C	C	4	8	7
	I	C	C	C	C	4		
23	A	C	C	C	C	4	8	7
	I	C	C	C	C	4		
24	A	N	N	C	N	1	3	2
	I	N	C	C	N	2		
25	A	N	N	N	N	0	0	2
	I	N	N	N	N	0		
26	A	N	N	N	N	0	0	1
	I	N	N	N	N	0		
27	A	N	C	C	C	3	7	6
	I	C	C	C	C	4		
28	A	N	C	C	C	3	6	6
	I	N	C	C	C	3		
29	A	N	N	N	N	0	0	2
		N	N	N	N	0		

TABLE 11--Continued

Subject Number	Judge	Clinical Stimulus Number 1	2	3	4	Number of Clinical Conservation Responses	Clinical Conservation Score	Behavioral Conservation Score
30	A	N	N	N	N	0	0	4
	I	N	N	N	N	0		
31	A	C	C	C	C	4	8	6
	I	C	C	C	C	4		
32	A	N	N	N	N	0	0	5
	I	N	N	N	N	0		

[1]A = Author's judgements

[2]I = Independent judgements

[3]N = Nonconservation responses

[4]C = Conservation responses

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