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THE ROLE OF LANGUAGE, MANIPULATION AND DEMONSTRATION IN THE ACQUISITION, RETENTION, AND TRANSFER OF CONSERVATION

by

© MOHINDAR SINGH RATTAN

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Role of Language, Manipulation and Demonstration in the Acquisition, Retention, and Transfer of Conservation" submitted by Mohindar Singh Rattan in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

The study was designed to investigate the role of language, manipulation and demonstration in the acquisition, retention, and transfer of mathematical invariance—a concept comprising a broad range of conservation tasks including two dimensional space, number, substance, continuous quantity, weight, discontinuous quantity, area and length.

The subjects, taken from a pool of grade one stratified sample of non-conservers (N = 90), were randomly assigned to four experimental groups and one control group. Each S in the experimental groups was given two 15 minute training sessions and each S in the control group received one brief (10-12 minutes) irrelevant training session. Post test 1 was administered one day after training, Post test 2 five weeks after training, and the final Transfer test approximately six weeks after training.

An analysis of variance was performed on a number of variables derived from the three criterion measures for all the treatment groups. Following significant F ratios, the difference between ordered means for the various training conditions and for the various variables was tested using the Newman-Keuls comparison. The results and conclusions in terms of the main hypotheses investigated were as follows:

1. Role of training: the hypothesis concerning the role of tuition in the enhancement of cognitive processes leading to the acquisition, retention, and transfer of the broad range of conservation

(mathematical invariance) was supported; on all the 13 variables derived from the criterion measures, the experimental Ss outperformed ($p < .01$) the control Ss.

2. Role of activity type: the hypothesis concerning the role of activity type, viz. direct experience vs observation learning in the enhancement of cognitive processes leading to the acquisition, retention, and transfer of mathematical invariance was supported. That is, for all the variables, no difference was found between the direct activity and observation learning groups under either of the two verbal conditions.

3. Role of Verbal level: the hypothesis concerning the role of verbal level in the enhancement of cognitive processes leading to the acquisition, retention, and transfer of mathematical invariance was supported. That is, for all the variables, high degree of verbalization proved significantly better ($p < .01$ for majority of comparisons) than low degree of verbalization under either of the two activity types.

Implications of the findings of the study in terms of theory, research, and educational practice were pointed out.

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TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

TABLE		PAGE

CHAPTER I

INTRODUCTION TO THE PROBLEM

An adequate description of the process of cognitive development whereby "unknown externals become known internals" has implications both for psychological theory and educational practice. Piaget's theory of intellectual development relies heavily on direct activity and incidental experience in explaining the formation and development of cognitive structures. Piaget minimizes the role of training and education, particularly the role of verbal instruction, in bringing about transition from one stage of intellectual development to another. This view is challenged by some American and Soviet psychologists, who generally emphasize that verbal didactic instruction plays a significant role in facilitating transition from one stage of cognitive development to another, and place less emphasis on direct experience than Piaget does.

Piaget considers conservation as a pivotal construct in the child's transition from the pre-operational to the operational stage. When the child is able to conserve he realizes that certain properties (e.g. quantity, number, etc.) remain invariant in the face of certain transformations (e.g. changing the object's form or shape). A number of investigations (Sigel, Roeper & Hooper, 1966; Lefrancois, 1966; Towler, 1967; Carlson, 1967; Gelman, 1967; Coté, 1968; Prokopczak, 1969; Sullivan and Brison, 1967; Goldschmid, 1968) have reported that the child's acquisition of conservation can be accelerated by special training. These studies, however, have not concerned themselves with the broad range of conservation (i.e. mathematical invariance) but have dealt only with aspects of the concept--such as conservation of number, conservation of substance and so on. A considerable number of intervention studies have not attempted to satisfy Piaget's (1964) criteria of stability and generalizability of the acquired concept. Further, there is no conclusive evidence (Carlson, 1967; Sonstroem, 1965) as to the relative importance of physical activity (manipulation) as contrasted with observation in accelerating transition from the pre-operational to the operational stage.

The present investigation addresses itself to the problems that are identified in the above discussion. The major purpose of the study is an attempt to clarify some of the issues involved in the theoretical controversy that exists between Piagetian and American-Soviet positions. The testing is done in terms of the acquisition of the broad concept of mathematical invariance embodying conservation of two dimensional space, number, substance, continuous quantity, weight, discontinuous quantity, length and area. The research design of the study includes the investigation of stability and generalizability of the acquired concept. More specifically, the purpose of the study is to determine:

(1) the role of experimental treatments (specified in the chapter on Method) in the acquisition, retention, and transfer of the concept of mathematical invariance;

(2) the role of direct activity (manipulation or transformation of objects by the subjects themselves), as contrasted with observation

(didactic verbal instruction in which materials are manipulated by the experimenter) in the acquisition, retention and transfer of the concept of mathematical invariance;

(3) the role of two degrees of verbalization (in connection with both direct activity and observation learning) in the cognitive re-organization leading to the acquisition, retention and transfer of the concept of mathematical invariance.

CHAPTER II

THEORETICAL BACKGROUND

Piaget and cognitive development

A considerable portion of contemporary Piagetian research has concerned itself with the transition in cognitive processes that occurs as the child advances from the intuitive stage to the stage of concrete operations. One of the most important features of this transition is the acquisition of various conservations. Conservation is defined as "the cognition that certain properties (quantity, number, length, etc.) remain invariant (are conserved) in the face of certain transformations (displacing objects or object parts in space, sectioning an object into pieces, changing shape, etc. (Flavell, 1963, p. 245)." The importance of conservation is that it implies logical operations (Inhelder & Piaget, 1964) and allows the child "to handle the transformations of the physical world in reality and in thought (Inhelder, 1962, p. 20)." Piaget (1952, p. 3) asserts: "Every notion, whether it be scientific or merely a matter of common sense, presupposes a set of principles of conservation, either explicit or implicit." Conservation is considered by Piaget as "a necessary condition for all rational activity."

An example of a conservation experiment is presented with a view to providing focus for the discussion on the subject. The classical paradigm for assessing the conservation of liquid is as follows.

The subject is presented with three cylinders--two of which are identical while the third one is different in height and diameter. The two identical containers (L1 and L2) are filled with water to the same level and the third container (L3) is empty. After the subject (S) is satisfied that the containers L1 and L2 have the same amount of liquid in them, the experimenter (E) pours the contents of L1 into the empty vessel L3, and asks the S whether the containers L2 and L3 have the same amount of water in them. If the S answers in the affirmative and provides a satisfactory explanation for the answer, he is considered to be a conserver.

Piaget (1967) suggests that cognitive development manifesting transition from non-conservation to conservation occurs through the 'equilibration process'--an internal process heavily dependent on activity and experience. This process is not supposed to work through external reinforcements, but rather by a process of mutual interaction and co-ordination of the subject's own activities. As these activities are placed into relationships by the child, logical inferences emerge. Mental operations leading to conservation are believed to be achieved through a four step equilibration process (Piaget, 1957). In step 1, the child 'centers' only on one dimension as a substance is transformed. For example, if liquid is poured from one glass to a narrower one, the child at this stage will focus his attention on one of the two dimensions involved in the transformation, i.e., height or diameter. In step 2, the child centers on the opposite of what he centered on before. That is, if he centered on height, now he centers on diameter and vice-versa. Co-ordination of two dimensions does not take place. In step 3, the child is able to bring both dimensions into focus at the same time; however, the cognitive co-ordination of both dimensions is not consistent. In step 4, the child accepts conservation in the face of transformations for now he can consistently focus on the two dimensions simultaneously. The first two steps comprise non-conservation thinking, the third step refers to the transitional period, and the fourth step results in the concept of conservation. Each of these theoretical evolutionary steps underlies the stages of cognitive development and is quite consistent with the types of answers given by children in the different stages when confronted with conservation problems.

What is the nature of mental operations which underlie the ability to conserve? A mental operation, according to Piaget, is an internalization of a physical action which can be performed upon objects. It was through children's answers to the question how they knew weight, substance, etc. were conserved that Piaget received an insight into the mental operations required for conservation. Piaget (1960) postulates that conservation becomes possible because of the child's use of mental operations such as multiplying relations and compensation, identity and reversibility. Wallach (1963) summarizes these operations as follows:

> (a) the ability to take account of joint effect of change in two perceived aspects of the material rather than being limited to considering only one aspect at a time with the result that compensatory changes can be noted; (b) the development of an atomic theory of matter--a conception that matter consists of smaller particles that simply change their positions with respect to one another when the shape transformations occur; and (c) an ability to hypothesize that a reverse change of the transformed shape back into the original could be performed (pp. 248-249).

How do the mental operations responsible for conservation emerge? Piaget maintains that cognition implies psychological operations grounded in logic and that the development of these logical operations results from direct and active commerce with objects of the real world: ". . . all logical problems arise in the first place from manipulation of objects . . . (Piaget, 1957, p. 12)," and cognitive development provides the structures to solve these logical problems. Aebli (reported in Flavell, 1962, p. 367) points out that Piaget "stresses the importance of engaging the subject in direct action vis-a-vis the content." The development of thought is not due to "stockpiling of information" or "insight" but is the result of a process of elaboration that is based essentially on the activity of the child (Inhelder, 1962, p. 20). Thus for Piaget, cognition at all developmental levels consists of actions performed by the person. At early levels of development the actions or operations are overt and physical. As the child matures, however, actions become increasingly internalized until covert actions, i.e., verbal, symbolic, formal operations dominate his processes of cognition. Flavell (1963) sees in the principle of internalization an implication for education. He suggests that the best way to teach a child some general principle or rule is to begin with action.

> That is, the child should first work with the principle in the most concrete and action oriented context possible, he should be allowed to manipulate objects himself and see the principle in his own actions (Flavell, 1963, p. 83).

A number of authors (Lovell, 1961; Dewey, 1916; Almy et al., 1966; Furth, 1969) seem to be in agreement with Piaget's emphasis on the necessity of activity for cognitive development.

Language and Cognitive Development

Sinclair-De-Zwart (1969), a psycholinguist, presents a summary of Piaget's conception of the role of language in cognitive development. Piaget considers language not to be a sufficient condition for the constitution of intellectual operations and as to the question of whether language is, "if not a sufficient, all the same a necessary condition" for them, Piaget leaves the question open as regards the operation of formal logic; and again, as regards concrete operations, "Piaget considers language not even a necessary condition for their constitution (p. 320)." Piaget holds that changes in cognitive structure are not accompanied via verbal enrichment or sophistication. "Language is not enough to explain thought because the structures which characterize thought have their roots in action and in sensori-motor mechanisms that are deeper than linguistics (Piaget, 1967, p. 98)." Piaget does not consider language as the source of logic, but on the contrary he suggests that language is structured by logic. Notwithstanding this position, Piagetians do not completely dismiss the importance of language. They concede that once the structures of thought are refined, language becomes necessary for their elaboration and mobility.

Although the value of verbal instruction for the development of cognitive structure and mental operations is seriously questioned by the Genevans, many American and Soviet psychologists take a very different position. For example, Gagné (1964) clearly points out the feasibility of using instructions as a 'genuine experimental variable.' He suggests that:

> instructions can serve any or all of four different functions in learning experiments: (1) identifying for the learner the nature of the performance to be learned, (2) directing attention to relevant stimuli, (3) stimulating recall of sub-ordinate capacities; and (4) guiding the thinking process (Gagné, 1964, p. 10).

Ausubel (1963, p. 116) suggests: "the stage of concrete operations is inaugurated when behavior and learning finally come under predominantly verbal and symbolic control." The child, in other words, can solve problems (e.g. conservation problems) by means of hypothesis generation and testing. As far as tuition in cognitive development is concerned, "didactic verbal exposition combined with concrete empirical props should be very effective (Ausubel, 1963, p. 129)."

Bruner (1966) suggests that more is involved in cognitive development than simple maturation via the internalization of logical forms. He conceives of development as the increasing internalization of technologies from the culture and emphasizes language in particular as the most effective technology available. According to Bruner, the world can be represented in three modes: enactive (through actions), ikonic (through images), and symbolic. Although there is a developmental sequence in terms of which--or more properly, of how many--of these modes are available to a person, all three remain in the system throughout life, and there is always interaction among them. For Bruner, the presence of conservation responses indicates that a transition from ikonic to symbolic representation has taken place and that it is brought about by the use of language which is considered as a program for ordering and integrating experience.

> Once the child has succeeded in internalizing language as a cognitive instrument, it becomes possible for him to represent and systematically transform the regularities of experience with far greater flexibility and power than before (Bruner, 1964, p. 4).

The release from the immediacy and overpowering impact of visual displays (in the conservation problems) is, in Bruner's thinking, probably closely related to the language of the child.

The neo-behavioristic approaches to cognition stress the importance of verbal mediation mechanisms in the development of thought (Erwin, 1960; Kendler, 1964; Mussen, 1964; Jensen, 1963, Blank & Solomon, 1968). It is argued that mediation and language are at the heart of reasoning. Kagan (1966) suggests that there are structural changes in the hierarchy in which the mediational units are organized and that the mediational structures are usually the basic explanation for age, sex, and individual differences in quality and flavour of reasoning and problem solving products.

Watson (1968) suggests that the act of transforming (in the conservation tasks) serves as the discriminative stimulus for the correct response to the subsequent conservation question. That is, the child must (1) discriminate a conserving transformation (reshaping) from a non-conserving transformation (adding or subtracting), and (2) remember the transformation when the third part of the sequence occurs. Watson's S-R analysis of the requirements of the task suggests that training should focus upon the child's capacity to discriminate and remember transformational acts. It seems reasonable, therefore, that the child must have an understanding of the language concepts required of the tasks, at a level that will facilitate its use as a mediator of discrimination. This includes the 'time-binding' function of language.

Developments in Soviet psychology have also pointed out the importance of language as a system of controls on various types of problem solving activities in children (Vygotsky, 1962; Luria, 1959, 1961, 1969; Sokolov, 1959). Luria views 'the word' as a hastener of mental processes and development; he explains that "the word connected with direct perception of the object, isolates the essential and inhibits the less essential properties of the object (such as its weight or shape) (Luria, 1959, p. 13)." As a result, the child establishes verbally complex connections and relations between perceived phenomena; this introduces essential changes in the perception of things influencing him. The non-conserver's inability to center on more than one dimension at a time may be viewed, in this context, as somehow related to the verbal connections the child has at his command.

Luria (1969) discusses further the important role verbal instruction can play in cognitive development. In doing so, he gives rather complete summaries of supporting, empirical research carried out in the Soviet Union. Concerning the non-conserver's inability to cope with the visual distortions that occur when a substance is transformed from one shape to another, Luria (1961, p. 13) points out that verbal instruction "inhibited impulsive responses to immediate impressions, and made it possible for generalized behavior patterns to be formed . . ."

The role of mediation is undoubtedly critical for cognitive development, but the relative importance of various types of mediation is still debatable. Luria (1957) suggests that a sensori-motor type of mediation is of greater importance than verbal mediation for the child under five and one-half years of age. He states that in the early stages of development, speech is only a means of communication with others. Later on (i.e. after about five and one-half years of age) it becomes also a means whereby the child organizes his own experiences and regulates his own activities. So the child's activity now becomes verbally mediated.

Vygotsky (1962) sees a stronger role played by language processes in cognitive development. While he theorizes that thought and speech arise independently in the nervous system, he postulates that, when private speech develops, the two systems fuse, and that complex logical thinking depends upon interiorized speech. He was concerned with "the investigation of how a function, arising in communication and at first divided between two people, can restructure all of the activity of the child and gradually change into the complicated mediated functional system which characterizes the structure of his mental processes (Slobin, 1966, p. 130)." The Soviet research tends to indicate the possible importance of direct learning of verbal rules and principles in the conservation problems which involve perceptual refocussing. The Soviet viewpoint is summarized by Sokolov (1959) as follows:

> . . . speech emerges not only as the means of expression of thought, but primarily as the means of their formation, the means of analysis and synthesis, abstraction and generalization of material reality, and the material of logic operations is constituted by all of these sense (felt and perceived) data of material reality (Sokolov, 1959, p. 669).

The importance of modeling to the acquisition of behavior has been pointed out by Bandura and Walters (1963). Bandura (1965) suggests two processes through which imitational or observational learning takes place. One process is learning by contiguity of stimulus sequences. During the exposure to modeling stimuli, sequences of sensory experiences occur and become integrated, later the recall of integrated sensory experiences will guide the observer's behavior in imitation.

The second process involves verbal descriptions. Once verbal labels are available for the subject, he can describe to himself the model's behavior as it unfolds and can learn these verbal descriptions. Their later recall can serve as cues for directing or guiding the subject through imitative responses. Luria and Yudovich (1959) assign considerable importance to adult models and language in the acquisition of higher mental processes. Lavatelli (1969), in her paper on 'Functional role of language in transition to concrete operational thought' suggests that the teacher or experimenter should model for the child the syntactical structures (such as those dealing with causality, inference, etc.) that support the logical operations in the training tasks.

Summary

The preceding review of theoretical perspectives on early cognitive development suggests that there exists a controversy between Piaget and his followers on the one hand, and American and Soviet psychologists on the other hand. Piaget's theory starts from the central postulate that motor action is the source from which mental operations emerge. "The action of the organism is central to the acquisition of the operations (i.e. ideas or strategies) which we require for coping with the world (Tuddenham, 1966)." The Geneva school feels that logical inconsistencies arising in direct and manipulative experience would result in cognitive reorganization and development. Consequently, the effects of external rewards on the acquisition of behavior are not considered to be of particular importance. Instead, in agreement with cognitive dissonance theory (Festinger, 1957), dissonance reduction, due to the development of logically appropriate cognitive structure, serves as an internal reward.

It would appear also that Piaget is not primarily interested in the possible effects of specific, deliberate didactic tuition of mental processes. In fact, as Sinclair-de-Zwart (1969) has stated, Piaget de-emphasizes the role of language to the point where it is not even considered as a necessary condition for the constitution of concrete operations--the operations that underlie the presence of conservation skills.

The American and Soviet psychologists generally stress the importance of verbal mediation in cognitive development. They suggest that language (verbal mediators) provides a means, not only for representing experience, but also for transforming it. They also place less emphasis on direct activity on the part of the child vis-a-vis his material environment. The position taken in this study does not deny the role of action in thought, nor does it assert the role of language unrelated to action (whether actually carried out, or observed or imagined). It emphasizes that language begins to give direction, articulation, and mobility to that action as soon as the child begins to actively acquire a grasp on the instrumentality of language, i.e. at an age prior to the onset of concrete operations.

CHAPTER III

REVIEW OF RELATED LITERATURE

Research Relevant to Understanding the Conservation Phenomenon

Validation of Piaget's formulation of the process of conservation has been undertaken, and generally the results have confirmed his stage-wise developmental progression (Dodwell, 1960, 1961; Elkind, 1961; Wohlwill, 1960; Hood, 1962; Almy *et al.*, 1966). However, Piaget's explanation for the developmental sequence fail to account adequately for differences in performance due to variations in the materials and procedures used in the assessment of conservation (Zimiles, 1963; Uzigris, 1964), and differences in performance on verbal and non-verbal criteria (Braine, 1959, 1962, 1964). Criticisms of this kind are not surprising when it is remembered that Piaget's conclusions were based on post hoc analysis of children's verbalizations. He never subjected his explanatory concepts to independent assessment to determine their value as predictors of conservation performance. When this has been attempted by others (Shantz & Sigel, 1967) the results have not always supported Piaget's contentions.

Bruner *et al.* (1966) argue with Piaget's position that inversion and compensation make conservation possible. According to Bruner inversion and compensation to be effective must rest upon an appreciation of the original equality (identity) of the quantities involved. In an attempt to clarify Piaget's position on conservation problems, Elkind (1967) has sharpened the distinction between the concepts of identity and equivalence. In solving the conservation problem presented to him, the child first makes a decision as to the equivalence of two aggregates as they stand side by side. Then, he must decide whether identity is preserved through the transformation of one of the aggregates. Finally, he must decide whether the two aggregates again are equivalent. Elkind suggests that Piaget tends to emphasize identity conservation even though the task in question assesses equivalence conservation. This is obvious from the fact that verbal explanations (identity, reversibility, compensation) are concerned with identity conservation.

Piaget (1967) criticizes Bruner and his associates (1966) for confusing: (a) pseudo-conservation with true conservation (true conservation requires an operational check on the S's response to a conservation task); (b) covariance of dimensions with compensation (covariance can be acquired by direct visual experience without comprehension); and (c) renversabilité (empirical return) with reversibility (operatory or logico-spatial concept). Piaget (1968) further argues that Bruner confuses the concept of identity and its relationship to conservation by emphasizing qualitative identity instead of quantitative identity. "Pre-operational qualitative identities can very well exist in situations where there is no sign of any of the fundamental rules of operations, such as reversibility and transitivity (Piaget, 1968, p. 21)."

A factor that may influence S's response in conservation task is his understanding of the relational terms 'more,' 'same' and 'less.'

If the S's knowledge of the relational terms has not been determined, failure on the conservation task may indicate that: (a) he does not understand the relational terms, (b) he can not conserve, or (c) both. Evidence supporting this reasoning comes from a number of investigations (Brison, 1966; Griffiths, Shantz & Sigel, 1967; Gruen, 1965; Braine & Shanks, 1965a, 1965b). Gruen (1965) suggests that minimal training in the use of relational terms tends to help children give conservation responses. Braine and Shanks (1965) suggest that a child may have the ability to perform a given operation such as conservation, without having the verbal skill necessary to adequately comprehend and respond to verbal techniques of assessing conservation.

Gruen (1966) points out that different procedures and criteria for assessing the presence or absence of conservation lead to different interpretations. Feigenbaum (1963) and Goldschmid (1968) have indicated that procedural variations such as length of the sausage or the comparison of a ball with a sausage rather than with a pancake may affect the child's judgment of conservation. Frank (1966) and Braine and Shanks (1965) define conservation in terms of making a distinction between real and phenomenal properties of an object (i.e. the correct choice in the test situation), while Smedslund (1961) will not consider any one a conserver unless he can give an adequate explanation for his answer. Pratoomraj and Johnson (1966) have shown that exact wording of the conservation question in the Piagetian clinical approach is not critical; therefore, slight variations within the general framework of conservation questioning is tolerable.

Bruner (1966) feels that the criteria (i.e. adequate explanation supporting conservation) used by Piaget are not sufficient for the conservation concept. If these logical reasons are not sufficient for the conservation concept, then any use of these reasons in determining the presence or absence of conservation is unnecessary. Piaget feels that logical sequence is psychological as well and, therefore, includes these justifications as criteria for conservation. An excellent account of the issue is given by Gruen (1966) who finds 5 year olds conserving using Bruner's criteria and when using Piaget's criteria, he finds 7 year olds, but few below that age, conserving.

Piaget and Inhelder (1941) have stated that conservation of substance is reached on the average around seven to eight years and conservation of weight around nine to ten years. Functional acquisition of volume occurs around eleven to twelve years. The invariant sequence of the development of substance, weight and volume conservation has generally been verified, with certain qualifications by a number of studies reprinted and reviewed by Sigel and Hooper (1968). However, the ages at which the various conservations appear are related to socio-cultural factors (Piaget, 1964; Goodnow, 1962). Smedslund (1959) found earlier transition ages for a group of children from a higher socio-economic milieu in Geneva. Sonstroem (1965) commented on the influence of socio-cultural factors in identifying non-conservers from two different schools. Almy et al. (1966) reported that lower class children show conservation of quantity and number a year later than middle class children. Sigel (1968) conjectures that perhaps this retardation in lower class children is related to their linguistic deficiencies. He points out that there is a "considerable support for the hypothesis that linguistic environments influence the quality of thought patterns, their rate of development, and variations in abilities with different types of problems" (Bernstein, 1961; Hess & Shipman, 1965; Sigel, Anderson & Shapiro, 1966).

There is some evidence (Smedslund, 1959; Feigenbaum, 1963; Goldschmid, 1968) that the acquisition of conservation and mental ability are related. However, the evidence is not conclusive. Brison and Bereiter (1967) report that the amount of training needed to acquire conservation of substance is not related to intelligence level. Lefrancois (1966) found a negative (but significant) correlation between the conservation post test and mental age for the treatment groups. However, the relationship between socio-economic status and ability to profit from training was both positive and significant. Lefrancois (1966) concludes that socio-economic rating may be a better predictor of success on conservation tasks than is mental age. It should be pointed out however, that mental age scores were mere approximations.

Review of Conservation Training Research

Piaget appears to minimize the effects of specific training procedures which may influence the individual's developmental transitions from one stage to another. There is a heavy emphasis on "inner organization and mutual co-ordination of the subject's schemata (Smedslund, 1961)" resulting from incidental experience involving direct activity. Several investigators have attempted to operationalize Piaget's equilibration model in the form of a training procedure for accelerating development

(Smedslund, 1961; Wohlwill & Lowe, 1962; Beilin, 1965) but the results have generally indicated the equilibration model to have little efficacy in bringing about conservation. Smedslund has formulated a 'cognitive-conflict' procedure in harmony with Piaget's speculations, and has reported some positive results. The training procedure is designed to induce cognitive-conflict in the child by pitting transformations of shape against addition and subtraction transformations before eliciting the child's judgment of amount in a series of trials. Coté (1968) has shown that a high standing on the dimension of flexibility enhances the possibility of developing a grasp of conservation through cognitive-conflict training. However, he did not find support for Smedlund's training procedure for his general sample. Kingsley and Hall (1968) also present evidence that is difficult to explain on the basis of Piaget's equilibration theory. Gruen (1965) has indicated that this mode of training only produces better results when it is accompanied by verbal pre-training.

While Piaget appears to de-emphasize the role of language in his equilibration model, he clearly emphasizes the importance of direct activity in the development of logical operations. Several findings, however, indicate that the role of direct experience with objects is not entirely clear. Carlson (1967), for example, found that direct experience in transforming substances was not more efficacious than simply watching the experimenter do the transformations. He did find support for the verbal mediation hypothesis in that his highly verbal instruction group outperformed ($p < .10$) his minimally verbal instruction group. Mermelstein and Meyer (1968), using a variety of procedures, concluded that direct manipulation had little bearing on the processes involved. Certainly, many of the successful training techniques have not involved manipulation (Beilen, 1965; Sullivan, 1967; Engelmann, 1967), and those that have provided manipulation have not always been effective (Coxford, 1964; Kohlberg, 1968). Galperin (1957) found that seven and eight year old Ss did better on a concept formation task in a demonstration situation as opposed to a direct activity situation.

Ausubel (1968) points out that theoretically there is no reason why only incidental experience must effect the gradual cumulative change in intellectual capacity that makes transition to a higher stage possible. Considerable evidence indicates that the use of various verbal procedures such as prior verbalization of principles, the use of verbal rules, verbal explanations, and confronting the child verbally with his own contradictions can accelerate the acquisition of conservation (Frank, 1964; Kohnstamm, 1966; Ojemann & Pritchett, 1963; Sullivan, 1966; Brison, 1966).

Sullivan (1967) reports an experiment that calls into question both Piaget's theory of 'action-equilibration,' involving the internalization of actual action and the manipulation of concrete objects, and Smedslund's theory of 'cognitive-conflict.' He suggests that coercion and suggestion by adult questioning in the cognitive conflict method may be minimized in a modeling procedure. The importance of modeling to the acquisition of behavior in children has been pointed out by Bandura and Walters (1963). Sullivan's study substantiated the hypothesis that conservation of substance could be induced in grade one children via a film mediated procedure. The induction was successful on the same substance as that used in the film, and generalization occured to a different substance. Generalization occured in both of his experimental (Verbal principle and no verbal principle) groups, but the hypothesis concerning the differential generalization between the experimental groups favouring the verbal group was not supported. However, when the post tests were placed seven days after the experimental treatment, the results were in line with the hypothesis of differential generalization and extinction between the Verbal Principle and No Principle groups. The hypothesis which predicted differences in extinction between the natural conservers and the acquired conservers was not upheld. This contradicts Smedslund's (1961b) findings on extinction. The Verbal Principle group was highly resistant to extinction. Sullivan notes that the use of adult film-mediated models to induce a higher form of mental activity (conservation) illustrates the paramount importance of the role that speech plays in higher mental processes.

Sonstroem (1965) tested predictions derived from both Piaget's theory of action-equilibration and Bruner's theory of internalization of technologies from the culture. More specifically, the predictions were that subjects in both manipulation and labeling treatments would learn conservation of solids more readily than comparable subjects without such training. The results indicated that both procedures were highly successful in inducing conservation: "but—and this is the most interesting fact of all—each of these worked <u>only</u> when the other was also present (p. 221)."

Sonstroem questions seriously the Piagetian view that conservation is the result of the internalization of actions and their conversion into operations governed by certain logical rules. He interprets his results in terms of Bruner's (1966) formulations in that by manipulation and labeling, the child was given ways of representing the problem that conflicted with the ikonic mode. In short, he was helped to cognize clay 'physically' and verbally,' instead of only perceptually. Sonstroem suggests that except for the interaction among the three modes of representation, learning could not occur. The findings of this study can be taken as offering support for the efficacy of verbal mediation procedures. The mediators were elicited from the child's own repertoire and involved language that had clear meaning for him.

Frank (Bruner, 1964) tested the hypothesis that activation of language would enable the child to be less dominated by perceptual forces in the setting, and consequently be able to deal with the conservation problem. He found that increased conservation responses occured under screened conditions and the older subjects maintained these responses in post test and transfer task situations.

Beilin (1965) attempted to induce conservation (number, length) in children (median age, 5 years and 4 months) by testing the possible differential effects of reinforcement and non-reinforcement, as well as verbal and non-verbal training procedures. In general, the training resulted in improved conservation performance. This improvement, however, was not uniform (either for age group or method) and the only training method that resulted in significant number of Ss improving, compared with the number improving within the control group was verbal rule instruction. The essential features of the verbal rule instruction procedure were:

> (a) the method was verbal, (b) an affective response was generated to failure which, hypothetically, could have led to greater subject attention and/or to cognitive uncertainty; (c) reinforcement was given, and (d) the procedure offered a model which was applicable to a variety of instances of the principle (Sigel & Hooper, 1968, p. 378).

Training did not prove to be sufficient to insure transfer to a conservation task (area) for which there was no training. Beilin also found that the training was somewhat more effective with older than with younger children.

The verbal pretraining in the Gruen (1965) study involved the terms 'more,' and 'longer,' and was closely related to the verbal training condition of other researchers (Beilin, 1965; Mermelstein et al., 1967; Carlson, 1967). It serves primarily to orient the child verbally to the appropriate cues in the situation and adds to the plausibility of the cue discrimination analysis of the task. Inhelder et al. (1966), however, warn that the Geneva group's attempt at training on the language of the task led to verbalizations that were task specific and possibly masked an inadequate comprehension of the underlying concept. In this case, Inhelder feels that verbalization of the rule could be a reflection of 'quasi-conservation'—a verbal facility with the rule of conservation that lacks generality and stability. Quasi-conservation may be differentiated from 'true' conservation through delayed post testing and the use of transfer measures.

Training based at least partially on the notion of reversibility has been successful for a number of investigators (Beilin, 1965; Wallach & Anderson, 1967; Wallach & Sprott, 1964; Goldschmid, 1968; Towler, 1967). In these studies the child was confronted with the fact that after transformation, the aggregate could be returned to its original configuration by an inverse transformation. This was usually accomplished by simply returning the materials to their original position. At times the effect was amplified by a verbal orienting statement, or by perceptual cues through the use of 'provoked' correspondence materials. In some cases the logical conclusion was drawn for the child; in others it was left for him to discover. The studies suggest that the training effects transferred to new sets of materials and that conservation responses were maintained by Ss over a period of several weeks. Wallach, Wall and Anderson (1967) suggest that recognition of reversibility and non-reliance on inappropriate cues may account for the acquisition of number conservation.

In contrast, Sigel, Roeper, and Hooper (1966) have provided training which centered on multiplication of classes, multiplication of relations, and reversibility—operations that Piaget has suggested as requirements for conservation. These researchers reported positive results for their training procedures, but several recent studies have placed in question the interpretation of their findings. Mermelstein et al. (1967) and Mermelstein and Meyer (1968) failed to confirm the Sigel, Roeper and Hooper results. Further, Meyer and Mermelstein (1968) found the prescribed sequence of training procedures, which Sigel and Roeper (1966) considered crucial, had no greater effect than a random sequence of the same procedures. They have offered the interpretation that all three elements of the training were not actually contributing to the effect. The possibility exists that the reversibility portion of the training was the sufficient cause of the gains in conservation. This would be consistent with the studies previously cited.

Engelmann (1967) achieved a significant increase in the conservation responses of kindergarten and grade one (N = 87) children through a presentation that involved the teaching of compensation reasoning, i.e. the ability to attend both to the height and the width of the object being transformed and to note that the changes in one dimension are balanced by compensating changes in the other. The emphasis was on observation rather than on active participation (manipulation of objects). More specifically, children worked not with the concrete objects but with their representations and the emphasis was on end states rather than the sequence of transformation. The results suggest that the difference between conservers and non-conservers can be expressed in terms of specific skills which can be taught in order to transport the child from the pre-operational to the concrete operational stage.

Gagné (1965) has developed an approach to learning which analyzes the material to be taught into a hierarchy of subtasks. Attainment of these subtasks provides a successful route to the mastery of a criterion task. Kingsley and Hall (1967) tested the efficacy of Gagné's approach in the training of conservation to young children. They concluded that task analysis proved to be very effective in defining behaviors which were needed for successful mastery of conservation. Lefrancois (1966) conducted a study that was based on a careful analysis of the subordinate capabilities involved in the conservation of substance with a sample of five and six year old children. He used a hierarchy of related tasks which were hypothesized to lead the subjects to an understanding of the concept. The results of his study indicated that both verbal and non-verbal methods were generally effective in helping the Ss attain conservation as measured by the post test and this effect was still evident when the Ss were re-tested after approximately a two week interval. Lefrancois also found that the verbal method (where the S was asked to explain and justify his responses) was superior to the non-verbal method.

Although Kohnstamm (1963) did not deal specifically with conservation problems, his training techniques are relevant to the present study. His training program involved verbal instructions, pictorial demonstrations, and guided practice in an attempt to teach class inclusion problems to five year olds. On the basis of his unqualified success with the experimental group, Kohnstamm feels justified in doubting the dominating role which Piaget and Inhelder attribute to action and their interiorization and the subordinate role they give to language as carrier of thought. He points out that the Genevans have not given any consideration to the possibility of other learning methods outside the scope of both passive empiricism and the equilibration theory. Kohnstamm (1966) deplores the minor role given to language in stimulating thought operations. He suggests that a training technique should be a very

> flexible combination of training sub-operations confronting the child with his own contradictions, making him use verbal rules to resist the misleading perceptual cues inherent in the problems, making his solution more stable and flexible by helping him through many different settings of the same problem, while at the same time discussing matters verbally with him and giving positive and negative reinforcements at that (Kohnstamm, 1966, p. 65).

Kohnstamm admits that this technique is sloppy from a methodological point of view, but appears sound from a pedagogical point of view where a teaching strategy must meet the needs of an individual child.

Gelman (1967), and Sigel and Roeper (1967) emphasize that attention must be paid to both state attributes and to transformations carried out on such state attributes. More specifically, it is argued that only by emphasizing the relevant aspects of the conservation tasks (nature of transformations) and de-emphasizing the irrelevant aspects (perceptual features) can there be hope for success in teaching conservation to non-conservers. Using this rationale, Prokopczak (1969) was able to induce conservation of length, mass, area, and liquid in a group of children (N = 20; mean age 7.8). He found that the experimental subjects showed significant gains over control subjects in the acquisition, retention and transfer tests of conservation. The training procedure allowed for optimal flexibility in communication and feedback between the examiner and the subject.

Goldschmid (1968) designed an experiment to assess the role that specific aspects of experience play in the acquisition of conservation. Two conservation scales (A and B) and a transfer scale (C) developed previously by Goldschmid and Bentler (1968) were used to assess the S's level of conservation. The experimental subjects (kindergartners, N = 100) were trained on two sets of tasks, half of them on discontinuous quantity, two dimensional space, and substance, the other half on continuous quantity, number and weight. Each half was further divided into three groups which were trained on reversibility, compensation, and a combination of reversibility and compensation respectively. Thus, each combination of tasks and training procedure was represented in one of the experimental groups. The first post test was administered three weeks, and the second post test (A) preceded by the transfer test (Scale C) six weeks after training.

The results of this study suggest that the acquisition of the principles (reversibility, compensation, and/or addition/subtraction) are indeed effective in eliciting conservation behavior. The overall effects of training clearly demonstrate ($p < .001$) that conservation can be induced in previously non-conserving children. The results also indicated specific as well as general transfer of training. It was also pointed out that reversibility training was more effective than the compensation and combination training, and that training on the first set of tasks (conservation of discontinuous quantity, two dimensional space, and substance) was more successful than training on the second set (continuous quantity, number and weight).

Summary of Training Research

A number of techniques have been used in attempts to accelerate the acquisition of conservation, but the results have varied widely. Some researchers have reported success in one training procedure or another, while others find it difficult to obtain any training effect. The total number of practice and training procedures, criteria and transformations used in these studies present quite a diversity. This diversity makes it difficult to gain a clear understanding of the combined results, but several general conclusions seem warranted.

1. Studies involving a single session with Ss have produced fewer significant results than those involving longer term training.

2. Training based on the exercise of relevant mental operations such as reversibility, compensation and identity--in conjunction with either perceptual cueing or verbal explanation of the rule has been effective in bringing about a change in conservation level.

3. Training involving various verbal didactic procedures (prior verbalization of principles, the use of verbal rules, filmed verbal explanations, confronting the child verbally with his own contradictions), in conjunction with concrete empirical props, has been effective in accelerating the acquisition of conservation.

General Hypotheses

On the basis of the review of theory and of relevant research literature, the following general hypotheses would seem justified. The specific hypotheses in operational terms will be presented following the specification of experimental procedures and the description of criterion measures.

1. A significant difference will exist between subjects (Ss) who receive experimental treatments and those who receive no treatment (control) in their performance on three post tests dealing with the broad range of conservation tasks.

2. No difference will exist between Ss who perform manipulations on the materials themselves and those who watch the experimenter (E) perform

the manipulations on their performance on three post tests dealing with the broad range of conservation tasks.

3. Experimental Ss with high degree of verbalization will outperform significantly the experimental Ss with low degree of verbalization on three post tests dealing with a broad range of conservation tasks.

Assumptions

1. Stratified random selection of Ss for the experimental and control groups ensures that all groups are equal in all ways that are critical to the experiment.

2. The extra-experimental influences are the same on all the experimental and control groups.

3. If differences between the groups, as indicated by the criterion measures, do exist they can be attributed to the differential effects of the experimental conditions.

4. The experimental conditions vary only on the dimensions indicated.

CHAPTER IV

METHOD

The Sample

The research sample consisted of 90 subjects who were drawn from the grade one population of three elementary schools in Red Deer, Alberta. In March, 1970, seven grade one classes (N 160) were tested on Raven's Progressive Matrices (Colored), on conservation of substance, and on verbal concepts (relational terms). These tests are described in a later section of this chapter. To be included in the final sample, a subject had to (a) pass the relational terms test, (b) fail the pre-test on conservation of substance, (c) score between the 10th and 90th percentile on the Raven's test, and (d) come from an English speaking home.

The subjects were randomly assigned to the five groups--four experimental and one control. Some descriptive statistics about the sample are given in Table I.

For comparison purposes, it should be pointed out that the age at which conservation is achieved spontaneously depends on the criterion level used (i.e. percentage of the age group that conserves). Lefrancois (1966) reports that using 50% criterion level conservation of substance and weight is reached by $7\frac{1}{2}$ and 8 years respectively. Using 75% criterion level, however, raises the respective ages to 9 and 10 years.

TABLE I

Sample Distribution by Sex, SES, Mental Ability (RPM), Age and Experimental Conditions

		EXPERIMENTAL CONDITIONS				
		High Verbal Demonstration I	Low Verbal Demonstration II	High Verbal Manipulation III	Low Verbal Manipulation IV	Control V
N		18	18	18	18	18
Sex	F	9	11	11	11	3
	M	9	7	7	7	15
SES	$\bar{X}$	43.17	44.44	44.00	43.72	43.63
	SD	12.20	15.46	13.99	11.38	12.27
RPM	$\bar{X}$	20.17	20.78	21.33	20.50	20.11
	SD	2.88	2.60	3.03	3.20	2.61
Age	$\bar{X}$	82.89	83.11	80.89	82.11	82.72
	SD	2.85	2.93	2.76	3.09	3.98

One way analysis of variance was performed to test the hypothesis that the average age, average ability level, and average socio-economic status of each of the five groups were the same. The results, as reported in Table II, did not reject the hypothesis for these three variables.

The Instruments

(1) The Concept Assessment Kit—Conservation. Consists of three scales. Forms A and B are parallel forms and each includes the

TABLE II

Analysis of Variance on SES, RPM, and Age for Experimental Groups
(k = 5, N = 18)

Variable	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
SES	Between	29.81	4	7.45	.05
	Within	13557.13	85	159.50	
RPM	Between	18.06	4	4.52	.55
	Within	701.89	85	8.26	
Age	Between	57.56	4	14.39	1.45
	Within	844.87	85	9.94	

$F_{.99}$ (4,85) = 3.55

following six tasks: Two dimensional space, Number, Substance, Continuous Quantity, Weight, and Discontinuous Quantity. Form C measures a slightly different dimension of conservation and includes the following two tasks: Area and Length. On each scale, the child's level of conservation is determined by his conservation behavior and his comprehension of the principle involved. Conservation behavior refers to the child's judgment of the relative quantity of two objects, one of which has just been manipulated by the examiner. Comprehension is assessed by the child's explanation for his judgment.

Goldschmid and Bentler (1968) point out that the tasks included in the KIT are highly interesting to children, easy to administer and score, and statistically sound. The authors provide evidence that all three scales are both highly homogeneous and demonstrate high internal consistency. The testing time is short: Forms A and B each take approximately fifteen minutes, Form C ten minutes. The reliability coefficients between Form A and Form B, and the first and second administration of Form C are .94 and .91 respectively.

(2) Socio-economic Status (SES). Blishen's (1967) socio-economic index for occupations in Canada was used to assess the Ss SES. Choice of this scale as opposed to another was dictated largely by the ready availability of information regarding father's occupations.

(3) Raven's Progressive Matrices (Colored)--1947. This test is designed for use with children about five to eleven years of age. The test is largely perceptual and it seems to measure present capacity for intellectual activity irrespective of acquired knowledge. Technical data with respect to reliability, stability, and prediction coefficients is given in Rattan (1966).

The Sequence of Events

The testing and training procedures of the study required one group and six individual sessions with each child. The order of events was the same with all children. The order and approximate time involved were as follows:

1. Administration of Raven's Progressive Matrices test (Group)--about 40 minutes.
2. Pre-tests on verbal concepts (relational terms) and conservation of substance--about four to six minutes.
3. Training session 1--six trials on conservation of two dimensional space and three trials on conservation of substance--about 12 to 15 minutes.

4. Training session 2—three trials on conservation of substance and six trials on conservation of discontinuous quantity—about 12 to 15 minutes.
5. Post test 1—Form A of the Concept Assessment Kit—about 15 minutes. Five weeks interim between Post test 1 and Post test 2.
6. Post test 2—Form B of the Concept Assessment Kit—about 15 minutes. Six weeks interim between Post test 1 and Transfer test.
7. Transfer test—Form C of the Concept Assessment Kit—about 10 minutes.

The Ss were randomly assigned to training conditions after pre-testing (item # 2 above) and after the Ss had met the criteria for selection (see under Sample). The transformations of the materials were the same for all experimental conditions (see Appendix A).

Pre-tests of Verbal Concepts

Each subject was first tested on his comprehension of the relational terms "as much," "not as much," and "more," the three phrases used in the Concept Assessment Kit. The S was presented with four balls of clay, two of which containing the same amount of clay (A and D), one containing markedly less clay than the others (B), and one containing more clay than the other three (C). The E asked the following questions:

(1) (Pointing to A): "Which ball has more clay than this one?"

(2) (Pointing to D): "Which ball has just as much clay as this one?"

(3) (Pointing to A): "Which ball has not as much clay as this one?"

Only those Ss who demonstrated an understanding of these terms were considered qualified for the pre-test on conservation.

Pre-test: Conservation of Substance

The S was shown a pair of identical balls of clay for each of two items of the pre-test. After the S was satisfied that the two balls had the same amount of clay in them, one of the balls was deformed while the S watched. At this point the E asked: "Does this one (pointing to the deformed ball) have as much clay in it as this one (pointing to the whole ball) or does one of them have more?"

The S was dropped from the study if he gave a conservation response that was backed by an appropriate explanation. An explanation was considered appropriate if the answer referred to or alluded to such logical reasons as reversibility, compensation, and identity. All subjects were retained for final selection of they gave non-conservation answers of the usual kind (e.g. "the deformed ball has more because it is longest," or "the ball has more because it is round," etc.). The Ss were also retained who first gave a conservation answer only to reject it immediately for a non-conservation one when they were questioned about it. It should be pointed out that there were no more than four Ss in this category.

Experimental Procedures

The procedures used in the study were developed and refined by the author in the course of a pilot study in 1969. All phases of the study were conducted by the author himself. The experimental Ss were trained individually on three tasks: two dimensional space, substance, and discontinuous quantity. Each S was given two fifteen minute training sessions spread over two days. There were nine trials in each session and none of the manipulations forming part of the three criterion scales were included in the training trials. Transformations of the training trials are indicated in Appendix A.

Experimental Condition 1. This was a high verbal demonstration (HVD) condition. E's focus was to demonstrate that the original quantity (in the conservation tasks) of material remained invariant no matter how the object's shape was transformed. The E performed a series of transformations including some involving addition or subtraction. The latter manipulations were performed in order to avoid generating a response set in the S, i.e. "they are always the same." More specifically, the following sequence of events took place in this experimental condition.

1. S's agreement with respect to the quantitative equivalence of two objects was secured.

2. The S was told to watch carefully while E performed a series of transformations as shown in Appendix A.

3. With each transformation meaningful labels were either elicited or provided or both, i.e. "you see, it is longer this way but shorter this way," or again, "it is flatter but thinner," etc.

4. After each transformation, the S was asked, "Now tell me, is there as much wood/clay/corn here (pointing to the non-changed shape) as there (pointing to the transformed shape) or does one have more?" (Q).

5. The response of the S was reinforced with knowledge of results (i.e. "yes, that is right" or "no, that is wrong").

6. The S was told to watch carefully while E changed the transformed shape back to its original shape and repeated the Q (see # 4 above).

7. The response of the S was again reinforced with the knowledge of results (see # 5 above).

8. After sequence numbers 5 and 7, the E provided verbal rules using appropriate syntactical structures to emphasize quantitative invariance (e.g. "it is the same amount because nothing was added or nothing was taken away," or "it looks different but really it is the same amount because we can change it back to its original shape" (while performing the inverse operation), or again, "it is more or less because a little piece was added or taken away."

The above sequence of events was followed for each of 18 trials in the two training sessions.

Experimental Condition 2. This was a Minimum Verbal Demonstration (MVD) condition and the same sequence of events were followed as under condition 1, except E did not go beyond giving the positive or negative reinforcement (i.e. sequence 8 was omitted).

Experimental Condition 3. This was a High Verbal Direct Activity (Manipulation) Condition (HMV). The general procedure was the same as under Experimental Condition I, except the S was told to carry out the described transformations himself.

Experimental Condition 4. This was a Minimum Verbal Manipulation condition. The general procedure was the same as under

Experimental Condition 2, except the S was told to carry out the described transformations himself.

Experimental Condition 5. This was the condition that was applied to the control group. Each S in the control group received one brief (about 10 to 12 minutes) irrelevant training session. This was done to counteract a possible Hawthorne effect and to help establish good rapport between the S and E.

After the Ss were assigned to their experimental conditions, a schedule was drawn up so that each S would have an equal amount of elapsed time between the first instructional session and the following meetings between the S and E. This was done to control the time factor which is undoubtedly important to cognitive reorganization leading to the acceptance of mathematical invariance.

The Criterion Measures

The criterion measures used in the study were the three conservation scales A, B, and C of the Concept Assessment Kit (Goldschmid & Bentler, 1968). Test administration and scoring was done according to the instructions given in the manual, except that the items I and II dealing with two-dimensional space and continuous quantity were omitted from Forms A and B of the kit.

Post test 1. Conservation Scale A was administered one day after the second training session. The scale has six tasks dealing with the conservation of two-dimensional space, number, continuous quantity, weight, and discontinuous quantity.

Post test 2. Conservation Scale B was administered five weeks after the training. This scale is a parallel form to scale A and includes the same six tasks.

Transfer Test. Conservation Scale C was administered approximately six weeks after the training and one week after Post test 2. This scale has two tasks dealing with the conservation of area and length.

Scoring

The scoring is done in terms of behavior and explanation scores. For behavior, the S's response is scored as correct if he says that the two objects are the same (in amount or number, or weight, etc. as appropriate). If the S indicates that they are not the same, his response is scored as incorrect. For explanation, the S's response is scored as correct only if his conservation behavior was scored as correct and if he comprehends one or more of the following principles:

> 1. Invariant quantity: "you did not add or subtract anything," "they were the same before and you did not change the weight (number, etc.);" etc.
> 2. Compensation: "This glass is taller, but it is also thinner," "the sausage is longer, but thinner;" etc.
> 3. Reversibility: "If we put this back into this glass, it would be the same;" "if we made this back into a ball, it would be the same," etc. (Goldschmid & Bentler, 1968, 5-6)

The explanation responses are scored as incorrect if the child's conservation behavior is incorrect or if his answers do not conform to the above principles.

Analysis of Data

One way analysis of variance was performed on the 13 variables derived from the three criterion scales for all the treatment groups. Following a significant F ratio, the differences between means for the various training conditions were tested using Newman-Keuls comparison (Winer, 1962). In some cases differences between means were tested using t-ratios (Ferguson, 1966).

Specific Hypotheses

1. A significant difference exists between Ss who receive experimental treatment (HVD, LVD, HVM, and LVM) and those who receive no training (control) in their performance on 13 variables derived from Form A (Post test 1), Form B (Post test 2), and Form C (Transfer test) of the Goldschmid and Bentler (1968) Concept Assessment Kit: Conservation.

2. No differences exist between Ss who perform manipulations on the materials themselves and those who watch the experimenter (E) perform the manipulations on their performance on 13 variables derived from Form A (Post test 1), Form B (Post test 2), and Form C (Transfer test) of the Goldschmid and Bentler (1968) Concept Assessment Kit: Conservation. More specifically:

(a) No differences exist between High Verbal Demonstration (HVD) and High Verbal Manipulation (HVM) Ss on their performance on 13 criterion measures derived from the three forms of the Concept Assessment Kit.

(b) No differences exist between Low Verbal Demonstration (LVD) and Low Verbal Manipulation (LVM) Ss on their performance on 13 criterion measures derived from the three forms of the Concept Assessment Kit.

3. Experimental Ss with high degree of verbalization will outperform significantly the experimental Ss with low degree of verbalization on seven criterion measures derived from Form A, Form B, and Form C of the Concept Assessment Kit. More specifically:

(a) A significant difference exists between High Verbal Demonstration (HVD) and Low Verbal Demonstration (LVD) Ss on their performance on seven variables derived from the three forms of the Concept Assessment Kit.

(b) A significant difference exists between High Verbal Manipulation (HVM) and Low Verbal Manipulation (LVM) Ss on their performance on seven variables derived from the three forms of the Concept Assessment Kit.

(c) A significant difference exists between High Verbal Demonstration (HVD) and Low Verbal Manipulation (LVM) Ss on their performance on seven variables derived from the three forms of the Concept Assessment Kit.

(d) A significant difference exists between High Verbal Manipulation (HVM) and Low Verbal Demonstration (LVD) Ss on their performance on seven variables derived from the three forms of the Concept Assessment Kit.

CHAPTER V

RESULTS

The results are presented in terms of several variables derived from Post test 1, Post test 2, and Transfer test data. It will be recalled that Post test 1 and 2 consist of six conservation tasks--two dimensional space, Number, Substance, Continuous Quantity, Weight, and Discontinuous Quantity. The transfer test consists of two conservation tasks--Area and Length. The variables Acquisition and Retention represent the total scores for two dimensional space, Substance, and Discontinuous Quantity--the training tasks for the experimental groups. The variables Transfer 1 (Post test 1) and Transfer 2 (Post test 2) represent the total scores for the conservation of Number, Continuous Quantity and Weight. The variable behavior consists of the total scores of the conservation tasks without explanation and the variable explanation consists of the total explanation scores for Post test 1, Post test 2 and Transfer test data. The variable Total involves the total of both conservation behavior and conservation explanation for the tasks in each of the three criterion scales--Post test 1, Post test 2, and Transfer test.

The results of the investigation are presented in terms of the hypotheses tested.

<u>Hypothesis 1</u>: Overall effects, stability and transfer of training.

Table III presents the analysis of variance data for the thirteen variables discussed above. The results indicate that the

TABLE III

Analysis of Variance on 13 Criterion Variables
for Experimental Treatments
(k = 5, n = 18)

Variable	Source of Variation	Sum of Squares	Mean Squares	Degrees of Freedom	F Ratio
Post test 1	Group	193.18	48.29	4	24.42
Behavior	Error	168.11	1.98	85	
Post test 1	Group	247.51	61.88	4	19.46
Explanation	Error	270.27	3.18	85	
Post test 1	Group	246.84	61.71	4	32.83
Acquisition	Error	159.77	1.88	85	
Post test 1	Group	160.18	40.04	4	16.94
Transfer	Error	200.95	2.36	85	
Post test 1	Group	794.60	198.65	4	26.16
Total	Error	645.50	7.59	85	
Post test 2	Group	184.29	46.07	4	24.66
Behavior	Error	158.83	1.87	85	
Post test 2	Group	324.55	81.14	4	26.74
Explanation	Error	257.94	3.03	85	
Post test 2	Group	245.51	61.38	4	30.49
Retention	Error	171.11	2.01	85	
Post test 2	Group	189.16	47.29	4	23.39
Transfer	Error	171.83	2.02	85	
Post test 2	Group	853.84	213.46	4	31.61
Total	Error	574.11	6.75	85	
Transfer test	Group	97.55	24.39	4	6.99
Behavior	Error	296.50	3.49	85	
Transfer test	Group	76.15	19.04	4	5.60
Explanation	Error	288.83	3.40	85	
Transfer test	Group	325.26	81.32	4	7.78
Total	Error	888.33	10.45	85	

$F_{.9995}(4,85) = 5.60$

experimental treatment affects significantly ($p < .0005$) the performance on each of these variables. Further analyses (Tables IV to VIII) reveal that the experimental groups significantly outperformed ($p < .01$) the control group on each of Post test 1 Behavior, Post test 1 Explanation, Post test 1 Acquisition, Post test 1 Transfer, Post test 1 Total, Post test 2 behavior, Post test 2 Explanation, Post test 2 Retention, Post test 2 Transfer, Post test 2 Total, Transfer test Behavior, Transfer test Explanation, and Transfer test Total variables.

It is quite clear that effects of training are responsible not only for acquisition of broad range of conservation (mathematical invariance) but also for retention (over five week period), and transfer—both specific (Forms A and B) and general (From C). The results definitely meet the high criteria set by Piaget (1964) for acknowledging genuine conservation acceleration.

TABLE IV

Newman-Keuls Comparison between Ordered Means for
Post Test 1 Behavior, Post Test 1 Explanation and Post Test 1 Total

Post Test 1 (Behavior)

Treatments		5	2	3	4	1
	Means	1.778	5.222	5.333	5.389	5.722
5	1.778	—	**	**	**	**
2	5.222		—	—	—	—
3	5.333			—	—	—
4	5.389				—	—
1	5.722					—

Post Test 1 (Explanation)

Treatments		5	2	4	3	1
	Means	.889	2.611	3.111	5.000	5.444
5	.889	—	**	**	**	**
2	2.611		—	—	**	**
4	3.111			—	**	**
3	5.000				—	—
1	5.444					—

Post Test 1 (Total)

Treatments		5	2	4	3	1
	Means	2.667	7.833	8.500	10.333	11.167
5	2.667		**	**	**	**
2	7.833			—	*	**
4	8.500				*	*
3	10.333					—
1	11.167					

** P Level < .01　　　* P Level < .05　　　— Not significant at .05 level

TABLE V

Newman-Keuls Comparison between Ordered Means for Post Test 1 Acquisition and Post Test 1 Transfer

Post Test 1 (Acquisition)

Treatment		5	2	4	3	1
	Means	1.389	4.167	4.389	5.889	5.944
5	1.389		**	**	**	**
2	4.167			—	**	**
4	4.389				**	**
3	5.889					—
1	5.944					

Post Test 1 (Transfer)

Treatment		5	2	4	3	1
	Means	1.278	3.667	4.111	4.444	5.222
5	1.278		**	**	**	**
2	3.667			—	—	*
4	4.111				—	—
3	4.444					—
1	5.222					

** P Level < .01   * P Level < .05   —Not significant at .05 level

TABLE VI

Newman-Keuls Comparisons between Ordered Means for
Post Test 2 Behavior, Post Test 2 Explanation and Post Test Total

Post Test 2 (Behavior)

Treatment		5	4	2	3	1
	Means	2.000	5.444	5.500	5.611	5.722
5	2.000		**	**	**	**
4	5.444			—	—	—
2	5.500				—	—
3	5.611					—
1	5.722					

Post Test 2 (Explanation)

Treatment		5	4	2	3	1
	Means	.667	1.722	2.778	5.056	5.611
5	.667		—	**	**	**
4	1.722			—	**	**
2	2.778				**	**
3	5.056					—
1	5.611					

Post Test 2 (Total)

Treatment		5	4	2	3	1
	Means	2.667	7.167	8.278	10.667	11.333
5	2.667		**	**	**	**
4	7.167			—	**	**
2	8.278				**	**
3	10.667					—
1	11.333					

** P Level $<.01$ * P Level $<.05$ --Not significant at .05 level

TABLE VII

Newman-Keuls Comparisons between Ordered Means for
Post Test 2 Retention and Post Test 2 Transfer

Post Test 2 (Retention)

Treatment		5	4	2	3	1
	Means	1.333	3.722	4.611	5.611	5.944
5	1.333		**	**	**	**
4	3.722			—	**	**
2	4.611				—	*
3	5.611					—
1	5.944					

Post Test 2 (Transfer)

Treatment		5	4	2	3	1
	Means	1.333	3.444	3.667	5.056	5.444
5	1.333		**	**	**	**
4	3.444			—	**	**
2	3.667				**	**
3	5.056					—
1	5.444					

** P Level < .01 * P Level < .05 —Not significant at .05 level

TABLE VIII

Newman-Keuls Comparisons between Ordered Means for Tranfser Test Behavior, Transfer Test Explanation and Transfer Test Total

Transfer Test (Behavior)

Treatment		5	2	4	3	1
	Means	2.278	4.333	4.667	4.889	5.222
5	2.278		**	**	**	**
2	4.333			—	—	—
4	4.667				—	—
3	4.889					—
1	5.222					—

Transfer Test (Explanation)

Treatment		5	4	2	3	1
	Means	.611	1.556	1.833	2.667	3.278
5	.611		—	—	**	**
4	1.556			—	—	*
2	1.833				—	—
3	2.667					—
1	3.278					

Transfer Test (Total)

Treatment		5	2	4	3	1
	Means	2.889	6.167	6.222	7.556	8.500
5	2.889		**	**	**	**
2	6.167			—	—	—
4	6.222				—	—
3	7.556					—
1	8.500					

** P Level < .01   * P Level < .05   — not significant at .05 level

<u>Hypothesis 2</u>: Differences in results of Manipulation and Demonstration training under two levels of verbalization

Tables IX and X —abstracted from Newman-Keuls Comparisons (Tables IV to VIII) for ready reference—present information bearing on hypothesis two. Table IX indicates that there are no significant differences between High Verbal Demonstration (HVD) and High Verbal Manipulation (HVM) training groups on Post test 1 Behavior, Post test 1 Explanation, Post test 1 Acquisition, Post test 1 Transfer, Post test 1 Total, Post test 2 Behavior, Post test 2 Explanation, Post test 2 Retention, Post test 2 Transfer, Post test 2 Total, Transfer test Behavior, Transfer test Explanation and Transfer test Total scores.

Table X indicates no significant differences between Low Verbal Demonstration (LVD) and Low Verbal Manipulation (LVM) training groups on the thirteen variables derived from Post test 1, Post test 2, and Transfer test data.

The evidence presented confirms the hypothesis of no difference between manipulation and demonstration training under both high verbal and low verbal conditions. Further, manipulation and demonstration training are equally effective in inducing mathematical invariance whether we use Bruner's criteria (Behavior scores only) or Piaget's criteria (Behavior plus explanation scores) for the presence of conservation.

TABLE IX

Newman-Keuls Comparisons for Differences between
High Verbal Demonstration and High Verbal Manipulation
Group Means on 13 Variables

		High Verbal Demonstration	High Verbal Manipulation	Newman-Keuls Comparison
Post test 1	$\bar{X}$	5.72	5.33	Not Significant
Behavior	SD	.46	.59	
Post test 1	$\bar{X}$	5.44	5.00	N.S.
Explanation	SD	.62	1.08	
Post test 1	$\bar{X}$	5.94	5.89	N.S.
Acquisition	SD	.24	.32	
Post test 1	$\bar{X}$	5.22	4.44	N.S.
Transfer	SD	.88	1.34	
Post test 1	$\bar{X}$	11.17	10.33	N.S.
Total	SD	.99	1.57	
Post test 2	$\bar{X}$	5.72	5.61	N.S.
Behavior	SD	.46	.70	
Post test 2	$\bar{X}$	5.61	5.06	N.S.
Explanation	SD	.61	1.63	
Post test 2	$\bar{X}$	5.94	5.61	N.S.
Retention	SD	.24	.98	
Post test 2	$\bar{X}$	5.44	5.06	N.S.
Transfer	SD	.72	1.55	
Post test 2	$\bar{X}$	11.33	10.67	N.S.
Total	SD	1.03	2.14	
Transfer test	$\bar{X}$	5.22	4.89	N.S.
Behavior	SD	1.40	1.45	
Transfer test	$\bar{X}$	3.28	2.67	N.S.
Explanation	SD	1.64	2.43	
Transfer test	$\bar{X}$	8.50	7.56	N.S.
Total	SD	2.83	3.43	

TABLE X

Newman-Keuls Comparisons for Differences between Low Verbal Demonstration and Low Verbal Manipulation Group Means on 13 Variables

		Low Verbal Demonstration	Low Verbal Manipulation	Newman-Keuls Comparison
Post test 1	$\bar{X}$	5.22	5.39	Not Significant
Behavior	SD	1.39	0.98	
Post test 1	$\bar{X}$	2.61	3.11	N.S.
Explanation	SD	2.25	2.42	
Post test 1	$\bar{X}$	4.17	4.39	N.S.
Acquisition	SD	1.54	1.46	
Post test 1	$\bar{X}$	3.67	4.11	N.S.
Transfer	SD	1.65	1.53	
Post test 1	$\bar{X}$	7.83	8.50	N.S.
Total	SD	3.01	2.85	
Post test 2	$\bar{X}$	5.50	5.44	N.S.
Behavior	SD	1.20	.98	
Post test 2	$\bar{X}$	2.78	1.72	N.S.
Explanation	SD	2.18	2.05	
Post test 2	$\bar{X}$	4.61	3.72	N.S.
Retention	SD	1.72	1.27	
Post test 2	$\bar{X}$	3.67	3.44	N.S.
Transfer	SD	1.37	1.25	
Post test 2	$\bar{X}$	8.28	7.17	N.S.
Total	SD	2.72	2.38	
Transfer test	$\bar{X}$	4.33	4.67	N.S.
Behavior	SD	1.78	1.85	
Transfer test	$\bar{X}$	1.83	1.56	N.S.
Explanation	SD	2.07	1.38	
Transfer test	$\bar{X}$	6.17	6.22	N.S.
Total	SD	3.42	2.67	

Hypothesis 3: Differences in results of High Verbal and Low Verbal training under demonstration and manipulation conditions

Tables XI to XIV--abstracted from Newman-Keuls Comparisons (Tables IV to VIII) for ready reference--present information bearing on hypothesis three.

Table XI presents probability levels for differences between High Verbal Demonstration (HVD) and Low Verbal Demonstration (LVD) training on seven variables derived from the three criterion measures. Examination of the Table indicates that differences favoring high verbal condition are significant for Acquisition ($p < .01$), Transfer 1 ($p < .05$), Post test 1 Total ($p < .01$), Retention ($p < .05$), Transfer 2 ($p < .01$), and Post test 2 Total ($p < .01$). The difference between HVD and LVD Transfer test Total is not significant using the Newman-Keuls comparison. However, the difference favors ($p < .05$, t test), the high verbal condition.

Table XII presents probability levels for differences between High Verbal Manipulation (HVM) and Low Verbal Manipulation (LVM) training. Examination of the Table indicates that differences favoring high verbal condition are significant for Acquisition ($p < .01$), Post test 1 Total ($p < .05$), Retention ($p < .01$), Transfer 2 ($p < .01$), and Post test 2 Total ($p < .01$). The other differences are not significant at the .05 level using Newman-Keuls comparison. However, the difference between HVM and LVM Transfer Test Total favors ($p < .10$, t test), the high verbal condition.

Table XIII gives probabilities for differences between High Verbal Manipulation (HVM) and Low Verbal Demonstration (LVD) training

TABLE XI

Probability Levels for Differences between High Verbal Demonstration and Low Verbal Demonstration Group Means on Seven* Criterion Measures

Criterion Measure		High Verbal Demonstration I	Low Verbal Demonstration II	Newman-Keuls Comparison
Acquisition	$\bar{X}$	5.994	4.167	$p < .01$
	SD	.24	1.54	
Transfer 1	$\bar{X}$	5.222	3.667	$p < .05$
	SD	.88	1.65	
Post test 1 Total	$\bar{X}$	11.67	7.833	$p < .01$
	SD	.99	3.01	
Retention	$\bar{X}$	5.944	4.611	$p < .05$
	SD	.24	1.72	
Transfer 2	$\bar{X}$	5.444	3.667	$p < .01$
	SD	.92	1.37	
Post test 2 Total	$\bar{X}$	11.333	8.278	$p < .01$
	SD	1.03	2.72	
Transfer test Total	$\bar{X}$	8.500	6.167	not significant, but $p < .05$ using t test
	SD	2.83	3.42	

*For testing hypothesis 3, only seven of the 13 variables derived from the Concept Assessment Kit were used.

TABLE XII

Probability Levels for Differences between
High Verbal Manipulation and Low Verbal Manipulation
Group Means on Seven Criterion Measures

Variable		High Verbal Manipulation III	Low Verbal Manipulation IV	Newman-Keuls Comparison
Acquisition	$\bar{X}$	5.889	4.389	p <.01
	SD	.32	1.46	
Transfer 1	$\bar{X}$	4.444	4.111	Not Significant
	SD	1.34	1.53	
Post test 1 Total	$\bar{X}$	10.333	8.500	p <.05
	SD	1.57	2.85	
Retention	$\bar{X}$	5.611	3.722	p <.01
	SD	.98	1.29	
Transfer 2	$\bar{X}$	5.056	3.444	p <.01
	SD	1.55	1.25	
Post test 2 Total	$\bar{X}$	10.667	7.167	p <.01
	SD	2.14	2.38	
Transfer test Total	$\bar{X}$	7.556	6.167	Not significant, but p <.10 using t test
	SD	3.43	2.67	

for the seven variables. Examination of the Table indicates that differences favoring the high verbal condition exist for Acquisition ($p < .01$), Post test 1 Total ($p < .05$), Retention ($p < .05$), Transfer 2 ($p < .01$), and Post test 2 Total ($p < .01$). The other differences are not significant at .05 level using Newman-Keuls comparisons. However, the difference between HVM and LVD Transfer 1 and Transfer test Total favor ($p < .10$, t test), the high verbal condition.

Table XIV presents probability levels for differences between High Verbal Demonstration (HVD) and Low Verbal Manipulation (LVM) training for the seven variables. Examination of the Table indicates that differences favoring the high verbal condition exist for Acquisition ($p < .01$), Post test 1 Total ($p < .05$), Retention ($p < .01$), Transfer 2 ($p < .01$), and Post test 2 Total ($p < .01$). The other differences are not significant at .05 level using Newman-Keuls comparisons. However, the difference between HVD and LVM Transfer 1 and Transfer test Total favor ($p < .01$, t test), the high verbal condition.

Thus, the evidence presented in Tables XI to XIV provide strong support for the hypothesis of the superiority of verbal mediation in the acquisition, retention and transfer of mathematical invariance.

Table XV presents a summary of results in terms of number of subjects who demonstrated conservation on various criterion measures derived from the concept-assessment kit. The subjects are classified conservers only if they provided a suitable logical explanation (Piaget criteria) for their conservation behavior.

TABLE XIII

Probability Levels for Differences between High Verbal Manipulation and Low Verbal Demonstration Group Means on Seven Criterion Measures

Variable		High Verbal Manipulation III	Low Verbal Demonstration II	Newman-Keuls Comparison
Acquisition	$\bar{X}$	5.889	4.167	$p < .01$
	SD	.32	1.54	
Transfer 1	$\bar{X}$	4.444	3.667	Not significant, but $p < .10$ using t test
	SD	1.34	1.65	
Post test 1 Total	$\bar{X}$	10.333	7.833	$p < .05$
	SD	1.57	3.01	
Retention	$\bar{X}$	5.611	4.611	$p < .05$
	SD	.98	1.72	
Transfer 2	$\bar{X}$	5.056	3.667	$p < .01$
	SD	1.55	1.37	
Post test 2 Total	$\bar{X}$	10.667	8.278	$p < .01$
	SD	2.14	2.72	
Transfer test Total	$\bar{X}$	7.556	6.167	Not significant, but $p < .10$ using t test
	SD	3.43	3.42	

TABLE XIV

Probability Levels for Differences between
High Verbal Demonstration and Low Verbal Manipulation
Group Means on Seven Criterion Measures

Variable		High Verbal Demonstration I	Low Verbal Manipulation IV	Newman-Keuls Comparison
Acquisition	$\bar{X}$	5.944	4.389	p <.01
	SD	.24	1.46	
Transfer 1	$\bar{X}$	5.222	4.111	Not significant, but p <.01 using t test
	SD	.88	1.53	
Post test 1 Total	$\bar{X}$	11.167	8.500	p < .05
	SD	.99	2.85	
Retention	$\bar{X}$	5.944	3.722	p <.01
	SD	.24	1.27	
Transfer 2	$\bar{X}$	5.444	3.444	p <.01
	SD	.92	1.25	
Post test 2 Total	$\bar{X}$	11.333	7.167	p <.01
	SD	1.03	2.38	
Transfer test Total	$\bar{X}$	8.500	6.222	Not significant, but p <.01 using t test
	SD	2.83	2.67	

TABLE XV

Number of Subjects Who Demonstrated Conservation on Various Criterion Measures for All Treatments (N = 18) and in Accordance with Piaget's Criteria

	High Verbal Demonstration	Low Verbal Demonstration	High Verbal Manipulation	Low Verbal Manipulation	Control
Criterion Measures	N	N	N	N	N
<u>Acquisition</u>					
1 2n space	17	10	17	10	3
2 Substance	18	10	18	9	3
3 D. Quantity	18	5	17	9	3
<u>Transfer 1</u>					
1 Number	17	10	14	12	2
2 C. Quantity	18	8	16	10	3
3 Weight	11	4	8	6	2
<u>Retention</u>					
1 2n space	18	11	16	7	2
2 Substance	18	11	16	5	2
3 D. Quantity	17	10	15	4	3
<u>Transfer 2</u>					
1 Number	17	6	16	8	1
2 C. Quantity	17	6	16	3	2
3 Weight	14	6	12	4	2
<u>Transfer test</u>					
1 Area	9	6	8	6	2
2 Length	9	4	7	0	1

CHAPTER VI

SUMMARY AND IMPLICATIONS

Summary of Results

1. Since the experimental Ss in the four treatment groups outperformed ($p < .01$) the Ss in the control group on the 13 variables derived from the criterion scales of the conservation assessment kit, it would appear

(a) that the broad concept of conservation (mathematical invariance) is subject to tuition for children of the age range included in this study;

(b) that the broad concept of conservation can be taught to Ss who are non-conservers, i.e. have not yet reached the transition stage to becoming conservers;

(c) that the conservation so acquired is not only retained but transfers to other conservation tasks (Piaget's criteria, 1964), some of which are generally regarded as being acquired at a much later stage.

2. Since no significant difference was found between the direct activity and demonstration treatment on any of the 13 variables derived from the three criterion scales of the conservation assessment kit, it would appear that direct activity (manipulation or transformation of objects by the Ss themselves) and observation learning (didactic verbal instruction in which materials are manipulated by the

experimenter, are equally effective for acquisition, retention, and transfer of the broad range of conservation (mathematical invariance) for Ss of the age range included in this study.

3. Since high verbal experimental groups showed significant superiority over low verbal experimental groups on most of the seven variables derived from the criterion scales of the conservation assessment kit, it would appear that providing the subject with verbal rules and potential verbal mediators acts as a facilitator of mental processes leading to the acquisition, retention, and transfer of the broad range of conservation (mathematical invariance) for Ss of the age range included in this study.

Implication of Results

For Theory

The results of the present study clearly support the position that appropriate training can facilitate basic cognitive processes leading to the acquisition, retention, and transfer (Piaget's criteria, 1964) of the broad range of conservation tasks. Thus, Piaget's position, that explains cognitive re-organization leading to the acquisition of conservation skills only or mostly in terms of spontaneous and incidental experience of the child must be questioned. The reluctance of Piagetians to accept the effects of specific training procedures which may influence the individual's developmental transitions from one stage to another may well be due to the possibility that they have not considered other training techniques "outside the scope of both passive empiricism and the equilibration theory" (Kohnstamm, 1963).

The results of the present study also challenge the position of those who are strong advocates of either direct experimentation or demonstration, as one technique may be just as good as the other depending, perhaps, on the type of concept to be taught, and the age of the child.

What turns out to be more important than type of activity, for the Ss in this study, is the level of verbalization in the experimental treatments. The high verbal didactic instruction in conjunction with either type of activity (i.e. direct experience or demonstration) shows significant superiority over low verbal instruction in inducing the acquisition, retention and transfer of mathematical invariance. However, if we accept conservation behavior without logical explanations (Bruner's criteria, 1966), the differences between high and low verbal instruction groups disappear. It could be concluded that verbal instruction only provides a handy rule which the children could give, and thereby be judged as conservers. This interpretation would appear to be false, however, if one considers the possibility that a concept can exist at different levels of sophistication. It is not unreasonable to claim that high verbal instruction develops a deeper and more sophisticated conception of mathematical invariance as the Ss become aware of the logical necessity of the conservation responses. The findings of no difference of behavior scores indicates that the Ss realize the logical necessity of the conservation responses, but did not have a fully developed concept of invariance. This is not to say that the Ss had only a "pseudo-concept"--as Piagetians would have us believe. They did have the concept, though at a less sophisticated level. These results support the view that concept formation or conceptual development is not an all or none affair, but that levels of understanding and sophistication exist and these should be recognized by research workers.

The experimental findings of the study seem to question Inhelder *et al.*'s (1966) contention that "language is not enough to markedly affect cognitive structures," as it would appear that language training (supplying the *S* with verbal rules and potential mediators) can bring about cognitive re-organization leading to the acceptance of mathematical invariance. Thus, Piaget's position, that the conservation concept is acquired from physical action and that language becomes important only after cognitive re-organization has occured, must be challenged.

The exact role that language plays in cognitive development is difficult to discern. Perhaps the better performance of the verbal didactic instruction groups is due to the fact that verbal instruction orients the child's thinking to the relevant features of the stimulus and/or that it provides a model or rule for processing relevant input data; the child then is released from "the overpowering appearance of visual display" and can operate at the level of symbolic representation. The present study generally supports the work done by Soviet psychologists such as Luria and Vygotsky, and American psychologists such as Bruner and Kendler in underscoring the importance and relevancy of the verbal mediation model for enhancing cognitive processes.

For Further Research

The results presented strong evidence favouring the verbal mediation hypothesis for the *S*s of the present investigation. However, it is recognized that the role of language vis-a-vis activity in cognitive development may be stronger for Ss who come from homes and cultures that stress the instrumentality of language from a very early age. Thus, to throw more light on the role of language in cognitive development, a study or studies could be designed to test the hypotheses of this study in relation to the child's preferred modes of perceiving and thinking—the modes that can be determined by studying the mother-child interaction (Schmidt, 1969; Brady, 1969; Hess & Shipman, 1965; Bernstein, 1961) either in the same or different socio-cultural groups. For example, it may be hypothesized that youngsters who have strong action orientation rather than strong language orientation may learn conservation skills better through a method that emphasizes manipulation training. However, as Blank and Solomon (1968) suggest, even for these youngsters the verbal mediation hypothesis may still hold; techniques utilizing relevant verbalization may develop language skills necessary for abstract thinking in conservation problems. Further, the role of tuition in conservation acceleration may also be studied in relation to personality variables such as cognitive style (Kagan et al., 1963, 1964, 1966, 1967) of the Ss. For example, the role of specific training method may be investigated in relation to conceptual tempo—basic disposition of the individual either to reflect upon his solution of a problem or to make impulsive and unconsidered responses.

For Educational Practice

The results of the study would appear to have a number of implications for educational practice in at least so far as the characteristics of the sample used is concerned.

1. Acquisition of certain basic concepts such as those embodied by the term mathematical invariance are subject to tuition if appropriate teaching strategy is employed. Since conservation concepts are considered essential for all rational activity, it is suggested that teachers can prepare the youngsters for other school activities by helping them acquire these concepts early in their school career.
2. Direct experimentation on the part of the student is not an indispensable condition for the occurrence of meaningful learning. Appropriate demonstration on the part of the teacher is equally effective for acquisition, retention, and transfer of concepts. However, it is recognized that some individuals may require experience with concrete materials before demonstration and verbal explanations can be maximally useful.
3. Instructional technique utilizing various verbal procedures, the use of verbal rules, verbal explanations, and confronting the child verbally with his own contradictions are superior to techniques emphasizing a minimum of verbal didactic instruction. It is suggested that the youngster can understand the syntactical rules of his language by the time he comes to school. The function of the school is to use language in conjunction with concrete materials as required, to help the child become actively involved in learning. Active involvement refers, not to motor activity, but rather to the internal mental manipulations of experience which will lead to the development of a symbolic system by which to process and organize experiential input.

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APPENDIX A

APPENDIX A

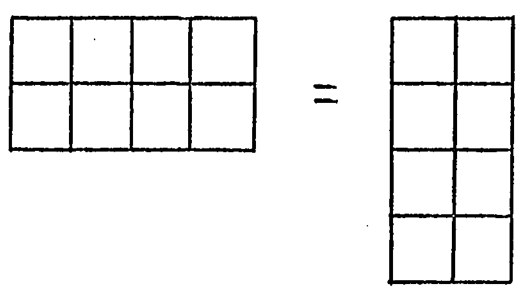
Materials used and procedures carried out in the training sessions are outlined below.

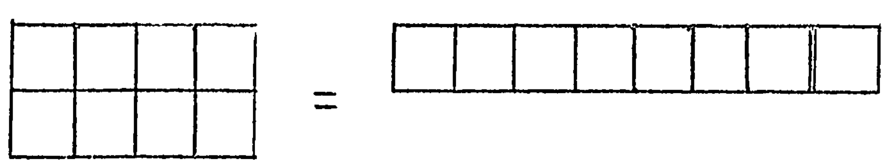
In all cases, the materials (shown in the diagrams) to the left of the equality sign were matched with their like so that the S had a referent. The transformation, done either by E or S depended on the experimental condition and occurred as depicted in the diagrams to the right of the equality sign.

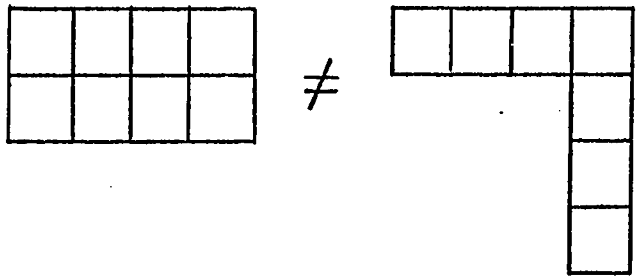
In some cases E, or S, added or removed some of the material. This is noted by "—added" or "—subtracted". The addition or subtraction of the material in the demonstration condition occurred in view and with the knowledge of S.

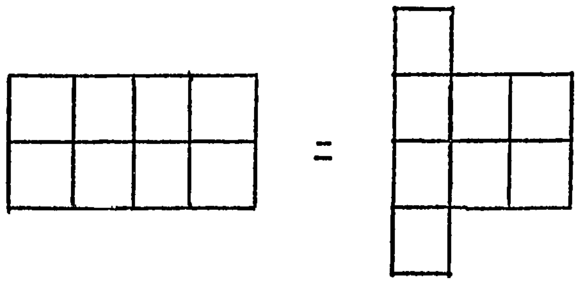
LESSON ONE

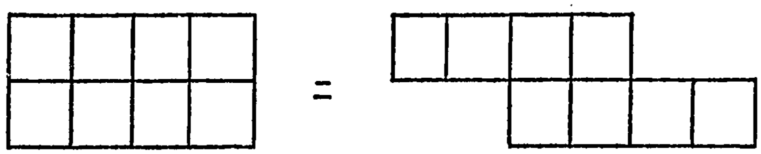
Wooden blocks were used for trials 1-6; plasticine was used for trials 7-9.

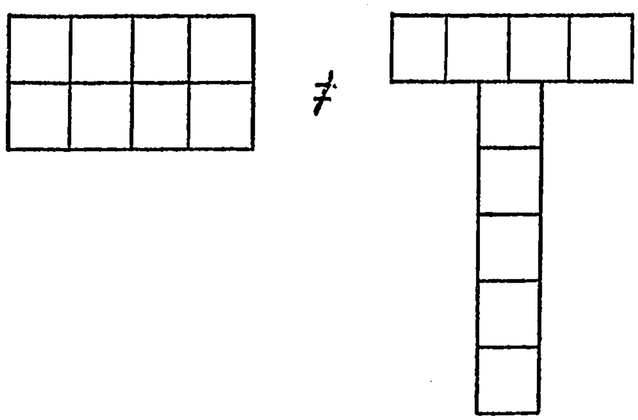
1. 

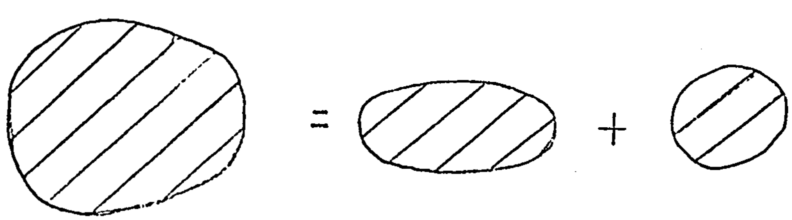
2. 

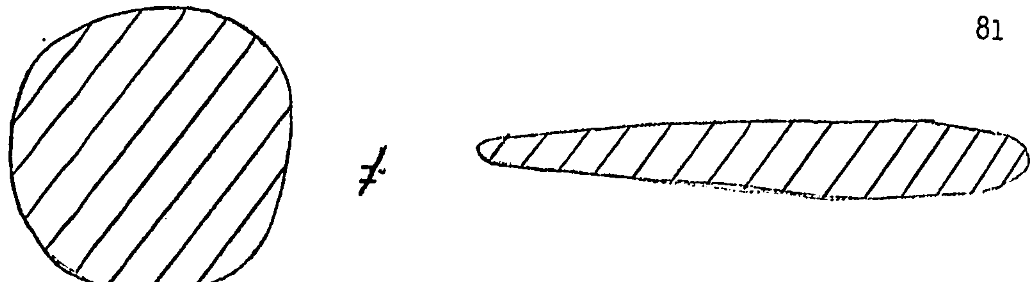
3.  (Block Subtracted)

4. 

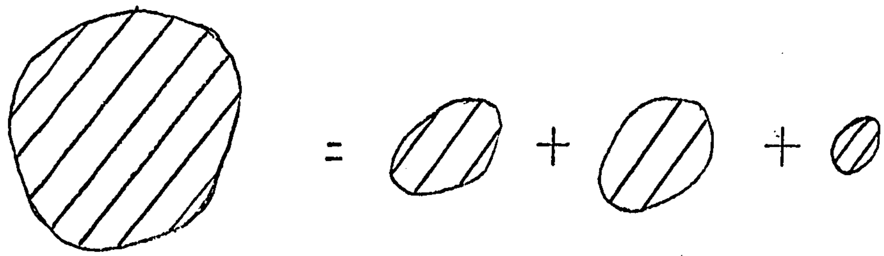
5. 

6.  (Block added)

7.  (Plasticene)

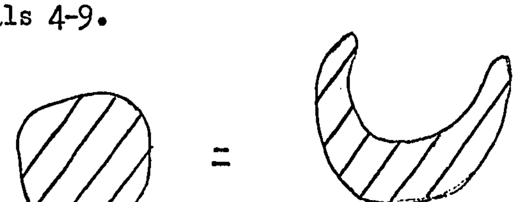
8. 

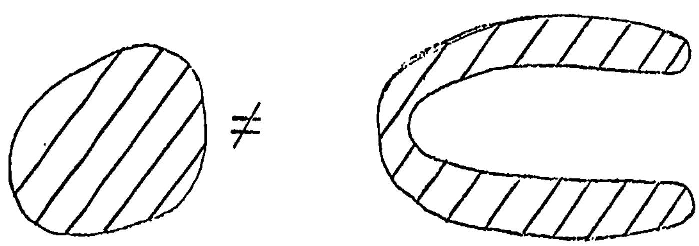
(Subtraction)

9. 

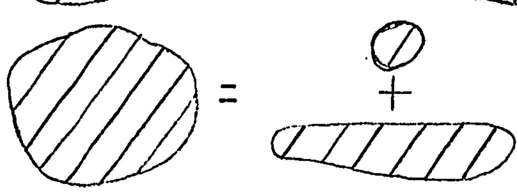
LESSON TWO

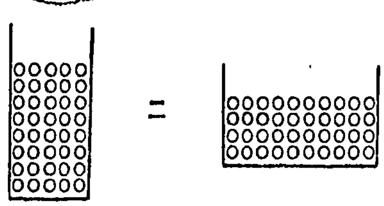
Plasticene was used for trials 1-3 and corn was used for trials 4-9.

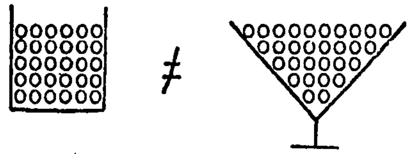
1. 

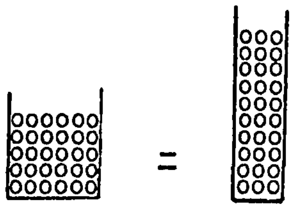
2. 

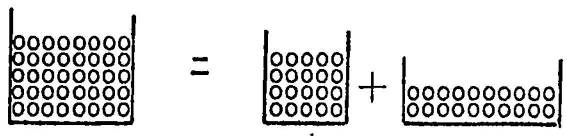
(Addition)

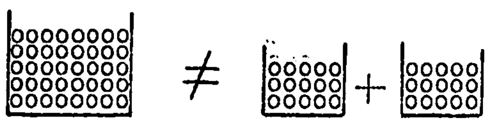
3. 

4. 

5.  (Subtraction)

6. 

7. 

8.  (Addition)

9.