

AN ABSTRACT OF THE THESIS OF

SHERMAN LE JEAL MCCLURE for the DOCTOR of PHILOSOPHY
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Title: THE APPLICATION OF COGNITIVE DISSONANCE THEORY
TO THE ACQUISITION OF A PIAGETIAN CONSERVATION
TASK BY SELECTED ELEMENTARY SCHOOL CHILDREN

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Fred W. Fox

Acquisition of the Piagetian conservation of substance task through perceptual training devices using three motivational levels and two verbal training levels constituted the basic ideas of this experimental study. The data collected was used to determine statistically if factors or interactions would be significant in inducing substance conservation.

The Ss range in age from 79 to 108 months and were obtained from seven public elementary schools in Oregon. Those Ss selected for the study were randomly assigned to interaction groups. One hundred and twenty-nine Ss completed the four interaction sessions, in which, they were seen individually by the E for a total time of one hour to one hour and ten minutes in five school days.

The first and fourth interaction sessions were the pre- and post-tests while the second interaction session was symbol training in the

expressions, less than, more than, and equal to. The third interaction session (perceptual training) used four sets of plastic holders and dowel stock classified according to length and diameter with the fourth set corresponding to Piaget's Grouping VII, the logical operation of multiplication of length and breadth. This last classification was never specifically stated as such, but classified as unequal length and unequal diameter with diameter decreasing and length increasing.

The motivational levels associated with the perceptual training were Festinger's Cognitive Dissonance, reward-nonreward, and non-cognitive dissonance where no reward was initially offered.

The verbal training levels consisted of Ss assigned to the verbal level who were questioned and given the classifications of the perceptual training devices if they were unable to do so. Those Ss assigned to the nonverbal level did not receive this instruction.

The posttest situation differed from the pretest by requiring the Ss to "pick out the sign (symbol) that tells us about the amount of clay here (and here)" in the two part conservation of substance (identity and equivalence) test.

Preliminary analysis of variance produced no significant age or sex differences between the main factors or interaction groups.

A test of independence was performed with respect to number of Ss giving conservation responses on the pretest (zero) and the number of Ss giving conservation responses on the posttest with results

significant beyond the .005 level.

A chi-square analysis of variance, after Wilson, was applied to the identity, equivalence and total frequency scores on the conservation of substance posttest. The cognitive dissonance motivational level was found statistically significant beyond the .10 and .05 levels for the total frequency score and the equivalence frequency scores respectively. Interaction of cognitive dissonance-verbal training was significant beyond the .10 level for the total frequency score and at the .10 level for the equivalence frequency score.

Among the recommendations stemming from this study are:

- (1) the use of simple perceptual training devices with cognitive dissonance and verbal training to provide nonconservers of substance with activities conducive to the acquisition of conservation of substance.
- (2) the pretesting of first and second grade children to ascertain the stage of conservation development and plan science activities accordingly.
- (3) the reevaluation of present training devices on the basis of the child's stage of conservation development.
- (4) the child should be permitted to make conservation discoveries for himself rather than being given the "correct" answer by the teacher.

The Application of Cognitive Dissonance Theory to the
Acquisition of a Piagetian Conservation Task by
Selected Elementary School Children

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Professor of Science Education
in charge of major

Redacted for Privacy

Chairman of Department of Science Education

Redacted for Privacy

Dean of Graduate School

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Typed by Donna L. Olson for Sherman Le Jeal McClure

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THE APPLICATION OF COGNITIVE DISSONANCE THEORY TO THE ACQUISITION OF A PIAGETIAN CONSERVATION TASK BY SELECTED ELEMENTARY SCHOOL CHILDREN

I. INTRODUCTION

The momentum generated by the development of new curriculum programs such as the Physical Science Study Committee (PSSC), Chemical Education Material Study (CHEMS), Chemical Bond Approach (CBA), and Biological Sciences Curriculum Study (BSCS) at the secondary level, carried to the junior high school in the form of new curricula which are typified by Introductory Physical Science (IPS), School Science Curriculum Project (SSCP), and Earth Science Curriculum Project (ESCP). The focus of this attention has now shifted to the elementary schools with a similar proliferation of alphabet curricula funded by federal agencies.

Fletcher G. Watson (1967) observes that statistically the secondary programs have been failures in the sense that present enrollment has not increased in physics and chemistry. Glatthorn (1968, p. 12) characterizes the curricula produced in the last ten years in the following manner:

They (the new programs) were devised by scholars, were subject centered, were supported by federal funding, were packaged by large corporations, and designed to appeal to the mass of schools. . . the major curriculum projects have done an excellent job of identifying the structures of

a given discipline but they have also left undone . . .

The "undone" of these secondary programs may be criticized from at least two major areas. First the programs were designed for the top students preparing for careers in science, and secondly, the lack of a psychological basis on which to build the curricula.

Those engaged in the development of the new elementary curricula are attempting to avoid these two basic mistakes. The programs are broad base, that is, the intent is inclusive of all normal children, the programs are integrated, and efforts are made for individual differences. Further, the programs such as the AAAS-Science a Process Approach (AAAS), Elementary Science Study (ESS), and Science Curriculum Improvement Study (SCIS) espouse a child oriented psychological basis.

The Psychological Basis of Elementary Programs

Much of the psychological foundation on which these elementary curricula are based has its origin in the work of Jean Piaget, Swiss director of the Jean Jacques Rosseau Institute in Geneva, Switzerland. Karplus (1967, p. 20-21) cites Piaget's work as the psychological basis for SCIS when he writes:

It is, therefore, the responsibility of the schools, to guide the children's development by providing them with particularly informative and suggestive experiences The awareness just described is due in large part to the Swiss psychologist Jean Piaget

In the older programs such as AAAS the influence of Piaget is seen in the discussion of the primary child whom Gagné (1965, p. 21) describes as an, "egocentric individual, incapable of handling many logical operations which are fundamental in adult manipulation of the world". These logical operations may be referred to Piaget's Concrete Operational Stage and certain conservation tasks which Piaget has empirically determined.

The importance of Piaget's work is exemplified in a description of the ESS program by Rogers and Voelker (1970, p. 38) that two important aspects of ESS supported by Piaget's experimentation are, "using concrete things and children's active involvement in learning".

Yet recent studies by Neuman (1969) and Allen (1967) found that children experiencing the new programs do no better than children experiencing traditional science programs when tested for conservation acquisition. However, Stafford (1969), in a comparison between traditional elementary science programs and SCIS, found a significant difference on Piagetian conservation tasks. The foregoing is not meant to imply the new programs were conceived to hasten the appearance of conservation tasks, nor was their prime goal the acquisition of these tasks. What does seem implicit is curricula based on Piagetian theory should provide a learning environment more conducive to the acquisition of conservation tasks. At this point the results of these programs seem equivocal.

Piaget's Developmental Psychology

Piaget's work with children has led him to formulate stages of development. These stages are described by Piaget (1964) as the:

- (1) sensory-motor, preverbal stage (0-2 years)
- (2) preoperational stage (2-7 years)
- (3) concrete operational stage (7-11 years)
- (4) hypothetical-deductive (formal) operational (11-15 years)

The age ranges assigned by Piaget are subject to variations arising from the cultural, social, and economic milieu of the child as described by Goodnow (1962) with Oriental children, or Greenfield on culture and conservation in Bruner (1964). In a paper on the implications of Piaget's theory for education, Sinclair and Kamii (1970) state the age acquisition may vary but the order of stages is invariant as is the order of conservation tasks in the concrete operational stage.

The developmental theory of Piaget is based on a logical system with operations forming part of its structure. Operations in a mathematical sense include such pairs of operators as \times (multiplication) and \div (division), $+$ (addition) and $-$ (subtraction), E (identity), and I (inversion through center). These latter two operators from group theory, when performed, produce transformations leading to equivalent representation rather than changes in the basic properties of the system. In a less quantitative manner Piaget (1964, p. 176) defines the

operations of a child in the following terms:

To know an object is to act on it. To know is to modify, to transform the object, and to understand the process of transformation An operation is thus the essence of knowledge; it is an interiorized action which modifies the object of knowledge. . . . An operation . . . is a reversible action: that is, it can take place in both directions, for instance adding or subtracting, joining or separating.

The "concrete operations" which, in part, specify the Concrete Operational Stage of development are described by an invariant developmental continuum of conservation tasks. The ordering of these conservation tasks is given by Phillips (1969, p. 67) as:

- (1) conservation of numerical correspondence (cardination)
- (2) conservation of quantity
- (3) conservation of weight
- (4) conservation of volume
- (5) conservation of classes
- (6) numbering (ordination)
- (7) egocentricity in representation of objects
- (8) egocentricity in social relations
- (9) estimating water lines
- (10) time, movement, and velocity.

An example of a conservation task is the ability of a child to follow two sets of objects (dolls, toy cars, etc.) consisting of equal numbers in each set through a series of operations. These operations may transform the interval spacings, or in some other manner change

one-to-one match without destroying the cardinal value of each set. The child has conservation of cardinal number if he maintains the numerical equivalence of the sets through the transformations.

The Dilemma of the Nonconserver

In this study the acquisition of conservation of substance by the child in the Concrete Operational Stage age group represents the general area of concern. For it is during this time that a child changes from a non-conserver to a conserver in substance.

There are some problems, however, prior to the development of conservations. The child attends to perceptual clues which are ambiguous and misleading. As an example, a child in the concrete operational stage is shown two glasses (same size) of water with equal levels and then observes the water from one of the glasses poured into a tall, thin glass where the level of water stands higher, he may assert that the glass with the higher water level contains more than the shorter, wider glass. This represents nonconservation of substance through a concrete operational transformation which has misleading perceptual clues.

The implication from the above example is that conservation tasks are prerequisite to the child's ability to engage in investigations which permit him to perceive of his physical and biological universe in a manner not made more ambiguous (at least to an adult point of view)

by attending to perceptions which are misleading and irrelevant to the specific activity of the child. Therefore, these conservation tasks and the child's ability to conserve have direct application as to the concepts in mathematics and science which the child can reasonably be expected to learn at a given age.

There is an explicit need to develop motivational and training procedures in the learning environment which will expedite the non-conserver of the concrete operational stage to acquire designated conservation tasks. For example, it is difficult to imagine teaching a non-conserver of length the concept of measurement. Not that the activities used in developing the concept of measurement would not be a learning situation for him. In point of fact, it might lead him to develop conservation of length. The question is whether such designed activities would be the most efficacious procedural method that could be developed.

Psychological Theory as the Basis of Predicting Motivation and Acquisition of Conservation

It seems that a fruitful approach to the problem of acquisition of the conservation of substance task is through the selection of a learning theory from which predictions may be made. These predictions of the motivating and learning potential may then be compared with the empirical results to accept or reject

the basic hypotheses.

One of the more recent cognitive field theories containing basic hypotheses permitting predictions to be generated is Festinger's Theory of Cognitive Dissonance. Festinger's formulations have been applied to the social situation, but never to the problem of conservation task acquisition in the concrete operational stage.

Cognitive Dissonance

Festinger's Cognitive Dissonance Theory was developed in the middle fifties and first published in 1957. The basic hypotheses (Festinger, 1957, p. 3) are:

- (1) The existence of dissonance, being psychologically uncomfortable, will motivate the person to try to reduce the dissonance and achieve consonance.
- (2) When dissonance is present, in addition to trying to reduce it, the person will actively avoid situations and information which would likely increase dissonance.

The last hypothesis has been modified by results of experimental data (Festinger, 1964, p. 155) in the following manner: ". . . there is a tendency to look more at consonant than dissonant material in the post-decision period, this tendency is small and is easily overcome by . . . the potential usefulness of dissonant material . . ."

This theory was developed to deal with motivational aspects of

behavior with respect to the feedback relationship between post-behavioral cognitions and prebehavioral cognitions after decision making, and their impact on future behavior. Cognitive dissonance is not a field or personality theory in the classical sense, as it tends to avoid the grand scale and comprehensive coverage exhibited by the older theories. The narrow limits of cognitive dissonance theory confines it to problems associated with decision-making and the motivational state produced by the decision once it is made.

Cognitions are defined by Festinger (1957, p. 3) as, "any knowledge, opinion, or belief about the environment, one's self, or about one's behavior", some, or all of which, need not be formally logical. From the definition of cognitions, cognitive dissonance arises as "non-fitting" relations among certain knowledges (cognitions) with respect to a specific situation.

For example, the child who was a nonconserver in the conservation of quantity problem with the glasses of water would see or feel nothing inconsistent or illogical in his answers and dissonance would not exist. The child is answering from a logically consistent system with respect to the level of his cognitive functioning. This is a most important point, for the logic of the non-conserver in the Concrete Operational Stage is not the logic of an adult or child who is conserving. Thus, those cognitions which an adult would hold as inconsistent, and hence dissonant, are consonant for the child.

Decision Making and Dissonance

Festinger (1964) describes experimental results which partition the decision-making processes into three distinct periods. First in the order of development is the predecision period which is marked by conflict, frustration, etc., but is characterized by an unbiased search for information. The predecision period is followed by decision making. Real consequences must obtain from the decision for the ensuing postdecision period to result in dissonance and dissonance reduction. Dissonance reduction may occur in one of three ways:

- (1) changing or revoking the decision
- (2) changing the attractiveness of the alternative involved in the choice
- (3) establishing cognitive overlap among the alternatives involved in the choice.

The magnitude of this dissonance is described by Secord and Backman (1964, p. 116) in the following ratio:

$$\text{Dissonance} = \frac{\text{importance} \times \text{no. of dissonance elements}}{\text{importance} \times \text{no. of consonant elements}}$$

Thus, from this ratio it is seen that the more nearly equivalent the dissonant and consonant elements become the greater the dissonance. This formulation is, of course, only a qualitative manner of expressing the concept of dissonance.

Both Waterman (1967) and Benedict (1967) report research which was interpreted as evidence for cognitive dissonance possessing general drive characteristics which place the organism in a highly motivated state.

Overt Behavior as the Source of Data

An important point made by Kendler (1952), and clearly stated by Campbell (1954, p. 167) is "all perceptual, cognitive, and learning theories are response theories. For all of them, the intervening variables are to be inferred from the responses made by the organism in specific situations". Therefore, whether the observed behavior is recorded under "reward-nonreward theory" or through the use of "cognitive dissonance theory" the individual's responses are recorded and not the experimenter's theoretical or atheoretical conceptualization of the problem.

Use of Cognitive Dissonance in the Study

Under the theory of cognitive dissonance it is proposed in this study that a child (nonconservers of substance) be exposed to a group of trinkets as reward items. The child is then asked to order the items with respect to their desirability (predecision conflict situation). Once the child has ordered the items the experimenter instructs the child that he is going to play a game. The rules of the game are that

if he answers the questions and problems in the following game he will receive the second of his choices. Otherwise, he will receive his third choice. The incorrect answers (decisions) are elicited from the child as a result of his centering on misleading perceptual clues and he is informed that his answers are wrong. The decisions have real consequences for he is to receive the lesser of two desirable objects. The child is now in what Festinger describes as the postdecision period and is experiencing dissonance. According to dissonance theory the child should be in a high motivational state. At this point the experimenter asks the child if he would like to play a new game to see if he can win his second choice. The situation is one that corresponds to dissonance reduction by changing or revoking the decisions in the previous game. The perception training is initiated by this activity. The motivational situation is the dissonance created by the child's decisions which resulted in the loss of his second choice. The responses made by the child in the posttesting situation which follows the perception training session are the recorded behaviors which will be designated as evidencing conservation or nonconservation responses.

At this point it seems relevant to ask whether a "reward-nonreward" situation is not the same as "cognitive dissonance" only under another rubric. For example, in reward-nonreward conditions the correct response is reinforced just as in the case of cognitive dissonance when the correct responses are made in the perception training

session.

There seems to be at least three ways in which a cognitive dissonance treatment differs from a reward-nonreward treatment. First, the motivation is assumed to occur when the child gives an incorrect answer in the cognitive dissonance treatment as opposed to the reward-nonreward treatment where the motivation occurs by way of reinforcement of the correct answer. Secondly, in the cognitive dissonance treatment there is always a reward whether the answers are correct or incorrect, but in the reward-nonreward treatment there is either reward or no reward. Third, the child in the reward-nonreward treatment is to receive his first choice while the child in the cognitive dissonance treatment is to receive his second choice if he answers correctly. Whether these are differences of kind or differences of degree seem to require incorporation into the experimental design. This is basically the rationale for the use of three motivational treatments which are cognitive dissonance, reward-nonreward, and noncognitive dissonance, in which, the child is not offered an initial extrinsic reward.

Verbal Proficiency

Piaget (1964) views language as dependent upon cognitive structures which then may be verbalized. The cognitive structures are not developed appreciably through verbalization and therefore, he accords

language a secondary position so far as development of logical operations and conservation tasks are concerned. This view is opposed by some American and Russian psychologists such as Carroll (1964), Luriiā (1959), and Bruner (1966). Ausubel (1963, p. 149) sums up in part the view of these researchers when he states that, "verbalization does more than just encode subverbal insight into words. It is part of the very process of thought which makes possible a qualitatively higher level of understanding" In the same vein, Ausubel (1965, p. 1031) writes, "why (Piaget) chooses explicitly to postulate qualitative continuity between the motor basis of early and later manifestations of thought while denying such continuity between the motor and verbal stages of symbolic representation is a complete mystery to us." Yet, Furth (1966, 1967) supports Piaget's position based on studies of deaf people.

Two studies, one by Mermelstein and Shulman (1967) using children without benefit of public schools and children with benefit of public school, found significant differences between verbal and non-verbal tasks, while Fletcher (1970) reports that language was not a major factor in his conservation of number experiment.

The position of verbal ability seems equivocal at this point in time, and as such should be controlled as far as possible with the various treatments to determine its effect. Therefore, two levels of verbalization will be utilized. One verbal level will require the child to

state the rules for certain performances in the perceptual training session, and if the child cannot state the rules they will be stated for the child by the experimenter. The other verbal level will be nonverbal in that the child will not be required to state rules for performances in the perception training session, nor will verbal rules be given by the experimenter.

All treatment groups will undergo a training session in which they will be instructed in symbol discrimination by the experimenter. The terms "more than" (greater than), "less than" (fewer than), and "equal to" (the same) will be used with nonconservation problems utilizing number and amount situations.

The Problem

The basic problem of this study is the statistical comparison of three motivational treatments used in conjunction with a two-level training procedure to determine which motivational technique is most significant in inducing conservation of substance in children not previously exhibiting this conservation ability.

The problem develops from the empirically determined "developmental stage" of the child as described by Piaget. These stages form part of the psychological base of present elementary programs.

Next in the development of this problem are the equivocal

experimental results obtained by comparison of children instructed in new and traditional elementary science programs when tested on conservation tasks. From these results it is assumed that the necessary and sufficient conditions (motivational environment impact) have not been developed in which the child can most efficiently achieve conservation. Rather than attempt additional collection of data based on positivistic paradigms, theory in the form of cognitive dissonance is used to predict a motivational environment which, coupled with pre-training and training procedures, should lead to the acquisition of conservation of substance.

II. RELATED RESEARCH

Introduction

Flavell (1963, p. 245) writes that:

one of the most important components of the transition from preoperational to concrete operational thought is the acquisition of various conservations, that is, the cognition that certain properties (quantity, number, length, etc.) remain invariant (are conserved) in the face of certain transformations (displacement of objects or object parts in space, sectioning an object into pieces, changing its shape, etc.).

The importance of this transition can not be over-stated for the majority of traditional elementary science textbooks and programs involve activities which are beyond the logical operations manifested by the majority of first and second grade students. Even though these children are in the chronological age range when concrete operations are expected to occur, they are still bound by perceptual misleading cues. They will, therefore, exhibit the characteristics of the younger preoperational stage children.

Only within the last decade with the modern elementary science programs has this transition to the concrete operational stage been acknowledged with the development of activities and materials employing this concept.

Horizontal Décalage

The sequence of conservation tasks within the Concrete

Operational Stage and the relative age ranges are described by Piaget and Inhelder (1941) as constituting an invariant developmental continuum. This view of a horizontal *décalage* has been validated by the replication studies of Elkind (1961a, 1961b, 1961c, 1961d, 1964), the studies in substance and weight by Smedslund (1960, 1961a, 1961b, 1961c, 1961d, 1961e, 1961f, 1962), Lovell (1966), Lovell and Ogilvie (1960, 1961a, 1961b), the studies in conservation of number by Dodwell (1960, 1961), Wohlwill (1960), Wohlwill and Lowe (1962), all of which give positive support for Piaget's work.

More recent work by Uzgiris (1964) using scalogram analysis concluded that conservation of substance, weight, and volume are achieved in that order further supporting Piaget. Berglund (1968), as part of her study, replicated Piaget's studies of conservation of continuous and discontinuous substance (quantity, matter, size, amount). The results confirmed the invariant stages of development reported by Piaget and other researchers. Lepper (1967-1968) used the Guttman Scalogram analysis in a cross cultural study of conservation of substance, number, length, and area which yielded further confirmation of Piaget's findings.

In conflict with these other studies is one reported by Achenbach (1969) that used optical illusions to create conflict in conservation of length, area, and volume. He found no horizontal *décalage* while working with normals and retardates. McManis (1969) also working

with normal and retardates found general agreement with Piaget's invariant order. In both cases it was found that mental age correlates with conservation better than chronological age.

Acceleration of Conservation Tasks in Preoperational Stage Children

There have been a large number of studies conducted to modify or in other ways accelerate the occurrence of various conservation tasks in young children of the preoperational stage. Studies by Wohlwill (1960), Wohlwill and Lowe (1962) in number conservation, Beilin and Franklin (1962) in area and length measurement, have been essentially negative. Others have reported success in the acceleration of conservation tasks such as Gruen (1965) with number conservation using internal conflict, Sigel, Roeper, and Hooper (1966) with conservation of quantity using multiple classification, multiple relations, and reversibility, Emrick (1968) with number, length, mass, and volume conservation using learning set and shaping technique, and Beilin (1965) using verbal rule instruction have obtained significant results with preschool children in their respective studies. It is instructive to note a study by Mermelstein and Meyer (1969) which used as treatments --cognitive conflict (Smedslund, 1961e, 1961f from whom Gruen obtained his internal conflict situation), verbal rule instruction (Beilin), multiple classification (Sigel, Roeper and Hooper)--to induce

conservation. Their results indicated the Piagetian concept of conservation was not induced by any of these training techniques.

Murktarian (1966) argues from his study that children in the pre-operational stage can obtain stable conservations across time. This work is supported by Rothenberg and Orost (1969) in conservation of number and Gelman (1969) in conservation of number and length.

The inclusiveness of the studies to date suggest a more pragmatic approach may be found in the selection of children whose chronological ages fall or nearly fall within the concrete operational stage.

Studies in Conservation Using Children in the Concrete Operational Stage Age Group

Several recent studies have been conducted using children whose general age range is in the concrete operational stage. Of these studies, Lee (1966) employed a screening technique and a questioning technique to provoke conservation of substance in children ranging in age from six years, four months to seven years, three months. The questioning group performed significantly better on all generalized tests than did the control group. Sullivan (1966) used filmed material models and verbal explanations. The children ranged in age from six years, four months to seven years, ten months. No significant difference existed between the experimental groups on the generalized posttest on conservation of clay and no significant difference was found

with respect to the verbal rule and no verbal rule treatments. In another study, Strauss (1967) randomly assigned children to four training groups which used combinations of cognitive conflict and the screening technique reported by Bruner (1964). The pretest conditions for assignment to groups was nonconservation or transition responses on conservation of continuous quantity (liquid) questions. Significant differences were found between the experimental and control groups, with conflict and screening more significant than screening alone. Additional support for age dependence of conservation of substance is supplied by Hermeier (1967) in a study which used children in kindergarten, 2nd grade, 4th grade, and 6th grade. A positive correlation was found between conservation of mass and age, and conservation of mass and intelligence. Studies involving verbalization have been reported by Carlson (1966) who used the two independent variables, direct experience-demonstration, and high verbal-minimum verbal training. His main conclusions were that high verbal instruction (rule giving) was more significant than minimum verbal instruction (no rule giving) and secondly, direct experience is better than demonstration. Peters (1968) has also used a verbal treatment (rule giving) and found this treatment to produce the greatest results in the conservation of number, while Overbeck and Schwartz (1970) and Kingsley and Hall (1967) support the above conclusions that verbal rule giving treatments are significantly more effective in studies focusing

on conservation of weight. Darnell (1969) describes a study in which the most effective treatment for conceptual rule learning and conservation concepts was class training (groups of five children) emphasizing negation. Brison (1965) achieved significant results in a group treatment consisting of practice in the conservation of inequalities of juice in a social group situation.

These studies have emphasized direct verbal rule giving of the conservation concept under consideration, direct training, screening and conflict taking place in group and individual experimental conditions. Within the context of these recent studies (1) extrinsic motivational paradigms associated with cognitive dissonance have not been used, (2) Piaget's theoretical position of the necessity of logical multiplication of height and breadth for the acquisition of the conservation of substance is not employed, and (3) the individual discovery of conservation through perception training which does not involve the materials used in pre- and posttests of conservation of substance has not been attempted. These are three major differences with respect to the present study and those previously conducted.

Verbal Factors in Conservation Acquisition

Sollee (1969) used children exhibiting a transitional state with respect to conservation of substance and found a significant correlation between verbal tests, verbal I.Q., and a composite verbal

competence scale and the conservation measures of number and quantity. The study failed to identify and differentiate those individual verbal factors most closely related to conservation. Mermelstein and Schulman (1967) in a comparison of children with and without public school for four years found a significant difference between verbal and nonverbal Piagetian conservation task performances.

With respect to the comprehension of comparative language, Smedslund (1969) cautions that it is imperative that the subject understand crucial words like bigger, smaller, more, less, same, etc. Supporting this contention is the work of Braine and Shanks (1965) who found that a majority of children under seven years of age tended to construe questions containing the word "bigger" as questions about apparent rather than real size, irrespective of whether the term "bigger" occurred in expressions as "really bigger" or "looks bigger". For older children Smedslund (1969) suggests the use of phrases such as "which one is really bigger", be used to avoid misinterpretation by the subject to responses requiring logico-mathematical processes (transitivity, addition, subtraction, multiplication). Smedslund (1966) found that 28% of the children in the study did not immediately grasp the term "less" in proper context and 12% did not employ the term "more" correctly. It has also been found by Lumsden and Potat (1968) that the concept of "bigger" is weighted for verticality.

A comparison of questions used in investigations of conservation

of substance is found in Fogelman (1969, p. 38). The standard question forms were:

Beard-- 'Is there still as much plasticine in the sausage as there is in the ball?'

Lovell and Ogilvie-- 'Who has the most plasticine now?'

Smedslund-- 'Do you think this contains more, or the same amount as, or less clay than the ball?'

Elkind-- 'Is there as much clay in the hot dog as in the ball, will they both have the same amount of clay?'

Uzgiris-- 'Is there as much clay in the ball as in the sausage?'

Of these standard forms Fogelman suggests that the least objectionable is that used by Smedslund. The question of biasing an answer by the use of statements which are loaded or suggestive is not supported by the work of Pratooraj and Johnson (1966, p. 343) who found that, "the kind of question had very little effect".

The evidence seems weighted toward the existence of a language effect on the level of communication between the experimenter and the child with respect to the phrasing of the conservation question and the meaning of words used in attempting to establish whether equality or inequality resulting from a transformation which changes only the shape of the clay exists for the child. The second question concerning verbalization of a concept and the development of the cognitive

structure of that concept seems undecided as previously stated. For the purposes of the study a symbol training session is effected to minimize the problem of word meaning, while a two level verbal training treatment will be used to determine if verbalization is an effect in this study.

Experimenter Bias

In comparisons of studies at least three sources of variation exist: experimenter, subjects, and experimental procedure. These sources of variation may also exist within a specific study and their control is essential if the results are not to be confounded by their presence. To this end subjects which give nonconservation answers on the pretest on conservation of substance are assigned randomly to groups and the experimental procedures are standardized by protocols to avoid experimenter inconsistencies in a less formal procedure.

The third source of variation, experimenter bias, is not controlled in this experiment, for example, by the use of other experimenters to remove this effect. This is not to say that an effort is not made to control experimenter bias. Fogelman (1969) found no experimenter bias in a conservation study using three experimenters, but Allen, Spear, and Johnson (1969) found significant differences in experimenters on conservation tasks.

Studies relevant to experimenter bias but not conducted in the

context of conservation tasks are those of Rosenthal (1963), Rosenthal and Lawson (1964) and Bandura and Huston (1961) which report significant evidence of experimenter bias. Rosenthal, Fode, Friedman, and Vikan (1960) found high correlation between experimenter bias and influence on the subject behavior when perceived as interested, enthusiastic, likeable, personal, pleasant-voiced, slow-speaking, expressive faced, expressive voiced, and using hand, arm, head, trunk, leg, and body gestures. Rosenthal et al. (1964a, 1964b, 1964c) extended previous work to show experimenter bias in sex of subjects and experimental hypotheses, experimental hypotheses and experimental results, and experimenter expectancy.

These studies are simply summed up by Dulaney (1962, p. 109) when he writes, "a human subject does what he thinks he is supposed to do if he wants to". Or as O'Donovan (1968, pp. 153-154) states, the "laboratory situation is an interpersonal confrontation", and in the case of this study the laboratory is a room in an elementary school where the experimenter is an unavoidable part of O'Donovan's interpersonal confrontation.

Summary

Experimental studies involving children in the preoperational stage age range are divergent in their results which leads to the conclusion that a more pragmatic approach is the use of children who

possess the general age range attributed to the concrete operations stage. Here practical application of ideas, techniques, motivational levels, and training devices may be used with first and second grade children if the results of the study have a positive nature.

Those studies on conservation tasks that have been conducted with children in the concrete operational age group have not employed the extrinsic motivational situation described by cognitive dissonance. Nor has Piaget's concept that the necessary condition for conservation of substance is the development of the logical operation of multiplication of length and breadth been employed in perceptual training devices that utilize the permutations of equal and unequal height and length of wooden dowels in plastic holders. By the logical operation of multiplication of length and breadth is meant that as the length of clay increases as it is rolled out, there is an inverse compensation in the decrease of the diameter. The training, in general has been direct with materials that are not used in the pre- and posttests but represent analogs of those which are manipulated. Within the limits of this study no direct training is given, nor do wooden dowels with their fixed shapes represent analogous materials or situations with transformations that employ deformations whose results call for a direct conservation interpretation. The assumption is that through the perceptual training which, in part, uses Piaget's logical operation of multiplication of length and breadth there is developed the necessary cognitive

structures for transfer to conservation of substance.

Experimenter bias in the form of a positive experimenter image is attempted for without the child's attending to the interpersonal training sessions and the materials which are used in these sessions there can be little hope of new cognitive structures pertinent to conservation acquisition being developed. On the other hand, effort is made to reduce experimenter bias to a minimum value with respect to biasing a child's answers to conservation questions. Questioning looks, answers couched as questions are met by a pleasant but, hopefully, equivocal expression. The experimental procedures in the pretest and posttest sessions require the experimenter, in as much as possible, to avoid verbal or nonverbal communications of such a nature as might bias the child's answer. This, in part, is reduced by requiring the child to state a reason for his answer for at no time during the interpersonal sessions are rules given that specifically describe the constancy of substance which results from a transformation by the simple process of deforming a substance such as clay.

III. THE STUDY

Experimental Design

Campbell and Stanley (1963) describe 12 factors which jeopardize the internal and external validity of experimental designs. Two methods for minimizing the effects of these confounding variables are the random assignment of subjects to treatment groups, and the limitation of treatment time.

The experimental design will consist of a pretest for the purpose of identifying the nonconservation of substance, and a posttest to determine conservation changes. The nonconservation is then randomly assigned to a treatment group. The general statistical design is a 3 x 2 factorial which has the general conceptual base of Design 4 in Stanley and Campbell (1963, p. 178).

Wein (1964, p. 479) gives the following advantages of factorial designs:

- (1) the interactions of two or more variables may be examined
- (2) the most efficient use is made of resources, in that all responses are used in estimating effects and mean squares
- (3) the results of the experiment may be applied over a wider range of conditions
- (4) there are usually more degrees of freedom for the residual mean square, this being particularly true in the fixed model.

The three motivational levels of treatment in the 3 x 2 factorial design are:

- a) CD, Cognitive Dissonance
- b) NCD, Noncognitive dissonance
- c) R, Reward-Nonreward

while the two levels of training are designated by:

- a) VT, Verbal Training
- b) NVT, Nonverbal training.

The interactions of this 3 x 2 factorial design are shown in the following table.

Table 3-1. Interactions of 3 x 2 factorial design.

Motivation		CD	NCD	R
Training	VT	CD-VT	NCD-VT	R-VT
	NVT	CD-NVT	NCD-NVT	R-NVT

Major Hypotheses

The three general hypotheses to be tested have the following null forms:

- H_{01} : There will be no difference between the three motivational groups in their performance on the conservation of substance test.

- H_{02} : There will be no difference between the two training groups in their performance on the conservation of substance test.
- H_{03} : There will be no interaction between subject membership in both independent variable groups and their performance on the conservation of substance test.

Minor Hypothesis

One minor hypothesis was tested which has the following form:

- H_{minor} : The two classifications (Ss giving non-conservation and Ss giving conservation responses on the pretest and posttest of conservation of substance) are independent.

Population

The Ss were first and second grade students from seven selected Oregon Public Elementary Schools (Hamilton Creek Elementary School, District 33-C; Crabtree Elementary School, District 110-C; Philomath Elementary School, District 17-J; Lacombe Elementary School, District 73-C; Liberty Elementary School, District 55; Tangent Elementary School, District 26-C; Lincoln Elementary School, District 509-J).

Assumptions

1. The protocol procedures developed by Piaget and others effectively identify the nonconserving subject.
2. The length of training is short enough to eliminate confounding by reason of maturation.
3. Random assignment eliminates the confounding variables of history, testing, statistical regression, selection.
4. The experimenter bias is minimized by the randomization procedure and the method used to ascertain conservation or nonconservation in the identity and equivalence posttest situation.
5. The pretraining in the symbols $>$, $=$, $<$, eliminates the problem of language understanding when the conservation questions are asked in the posttest.

Limitations

1. The study is limited to selected elementary school districts in Oregon.
2. The study is limited to the training of conservation of substance.
3. The study is limited to children who score as nonconservers on the pretests in conservation of substance, i. e. no

conservation answers on pretest.

4. The study is limited to children whose age places them in the concrete operational stage.

Operational Definitions of Motivational and Training Factors

Cognitive Dissonance Motivational Level

The subject, S, is instructed to order five items in the sequence of most liked to least liked. S is then instructed by the experimenter, E, that a game is to be played and the rules of the game call for the use of the second and third choices. The other items are removed with the second and third choices left in front of the S. E then informs S that if S answers the questions in the following game correctly S will receive his second choice, if S answers the questions incorrectly the third choice is his. The game is arranged so that the S answers the questions incorrectly. E then tells S how sorry he is that S lost his second choice (E moves the second choice closer to S) and slowly removes the game items from the training table. Fifteen to twenty seconds elapse during this clearing process at the end of which E tells S that he will give S another chance to win his second choice by playing another game (the perceptual training devices). Upon completion of the perceptual training the S is informed that he had won this second choice.

Noncognitive Dissonance Motivational Level

At the initiation of the perceptual training session the E informs S that today we are going to play a game using plastic holders and colored wooden pegs. No extrinsic motivation in the form of trinkets is offered until the completion of the perceptual training. S is then shown five items and is instructed to order them in the sequence of most liked to least liked. The S is then informed that he may have his first choice.

Reward-Nonreward Motivational Level

The S is instructed to order five items in the sequence of most liked to least liked. S is then informed by E that a game is to be played using the most liked item. The rules of the game are that S receives his first choice if he plays the game correctly and nothing if he does not play the game correctly. The perception training devices are then introduced. At the completion of the perception training session the S is informed that he has won his first choice.

Verbal Training Level

E asks S how each set of wooden pegs were the same or different after S has replaced them in their plastic holders. If S cannot verbalize the classification E points out the classification for S and has him

repeat the classification.

Nonverbal Training Level

E does not ask or give to S the classifications of the four sets of plastic holders and the dowels which constitute the perceptual training devices.

Interpersonal Sessions

The E works with the Ss on a one-to-one basis in a room provided by the elementary school. The Ss which qualify for the study by giving nonconservation answers on the first session will see the E a total of four times. These are:

1. The Pretest Session with a time range of 12 to 15 minutes.

During this time interval the pretests on identity and equivalence conservation of substance and conservation of length are administered and recorded.

2. The Symbol Training Session with a time range of 12 to 15 minutes. This session trains the Ss in the use of the symbols $>$ (more than), $<$ (less than), and $=$ (equal to). The S's understanding is inferred from responses given to comparison tasks.

3. The Perception Training Session with a time range of 15 to 20 minutes. This session encompasses the motivational

levels and the verbal levels of these independent variables.

The plastic holders containing wooden pegs with specific dimensional classifications designed to induce the logical operation of multiplication of length and breadth are manipulated by the Ss.

4. The Posttest Session with a time range of 10 to 15 minutes. The same materials and transformations are used, but the S is required to pick out of the white plastic tray the symbol which answers the standard question of which sign tells us about the amount of material after the transformations in the identity and equivalence conservation of substance tests. The conservation of length test is identical to that in the pretest session. The response and the reasons for the answers are recorded.

Identity and Equivalence Conservation

Elkind (1967), Hooper (1969), and Phillips (1969) have described the classical conservation question in terms of identity conservation and equivalence conservation with equivalence conservation subsuming identity conservation. The general method explicitly questions for conservation of equivalence and implicitly assumes conservation of identity to be occurring simultaneously with that of the conservation of equivalence.

The usual procedure is the presentation of, say, two clay balls which the S judges to be equal in the quantity of clay contained in each. One of the balls is transformed into a cross, ring or other shape. This transformation is followed by the classical conservation question "do we still have the same amount of clay or does one of us now have more clay?"

The question may be analyzed into its temporal parts in the following manner. Let B_1 and B_2 represent the clay balls and t_1 the time at which they are initially judged equal in amount of substance by the S. Let B_2' represent the transformation of B_2 and \rightarrow represent the transformation process at time, t_2 . Then the question is asked, "Is B_1 equal to B_2' ?" Symbolically the form is:

$$B_1 = B_2, t_1$$

$$B_2 \rightarrow B_2', t_2$$

$$B_1 ? B_2', t_3.$$

If S judges $B_1 = B_2'$ then E may infer the S judged $B_2 = B_2'$ and claim conservation of identity for S as well as conservation of equivalence.

Conservation of identity (number, length, substance, weight) is operationally the affirmation of equality after the transformation of a single object (no comparison object used). For example, the transformation of a single clay ball with no comparison ball, $B_2 \rightarrow B_2'$,

B_2 and B_2' and \rightarrow have the same meaning as above. The judgment of $B_2 = B_2'$ defines the conservation of identity or $B_2 \neq B_2'$ defines the nonconservation of identity.

In the classical question this is confounded with the conservation of equivalence which symbolically may be defined in the following manner.

S overtly judges $B_1 = B_2$, t_1

transformation $B_2 \rightarrow B_2'$, t_2

S covertly judges $B_2 = B_2'$, t_3

S overtly judges $B_1 = B_2'$, t_4

The last two equations may be judged unequal in which case E would define S as a nonconservers in equivalence for the specific conservation task under study, but in any case the E either implicitly or explicitly infers:

S judges $B_1 = B_2$

S judges $B_1 = B_2'$

E infers $B_2 = B_2'$.

Hooper (1969, p. 244) has found a "conceptual distinction with conventional Piagetian tasks." The findings indicate that conservation of identity precedes the development of conservation of equivalence. Thus, the present information seems to indicate a change in the traditional conservation of equivalence format to include identity testing, as well, in the pretest and posttest sessions on conservation of substance.

The Pretests

The pretest in conservation of length implicitly assumes conservation of identity for the questions test only for conservation of equivalence. The pretest on conservation of length serves three purposes:

1. The test provides a period of time for the S to overcome shyness and become acquainted with the E.
2. The test provides the S with an initial experience with judgment of length which is part of the classification used in the perceptual training devices.
3. The test provides the S with the experience of transformation with the attendant misleading clues.

The pretest of conservation of substance will be a two part test consisting of a conservation of identity set followed by a conservation of equivalence set.

The protocol procedures for the length and substance conservation sets are similar to those developed by Piaget and Inhelder (1941), Smedslund (1961b), Elkind (1961b), and others working in the Piagetian paradigm of conservation task acquisition. These protocols are modified for conservation of substance which is divided into identity and equivalence conservation tests. In all the sets (length, identity and equivalence of substance) the items are randomly presented and the

answers to the question of whether the length or the amounts are the same or different are recorded on student information sheets while the reasons are tape recorded on a Sony 350 tape recorder.

The Ss who are judged to be conservers are informed at the end of the pretest that more games are available, but there isn't time enough for everyone to come back. So, to decide who will come back the S will draw a chip from an opaque plastic holder which contains ten red and ten white chips. The red chips are "bad luck chips" and to draw one of these chips means there will not be time for the S to come back, while the white chips are "good luck chips" and there will be time for the S to come back and play more games. The same procedure is used with the Ss who have been judged as nonconservers. Three different containers are employed, one with all red chips, one with all white chips, and a third with both red chips and white chips. After the S has drawn a chip from the appropriate holder, the container is removed and the S is asked what the chip means. If he hesitates E supplies the answer and has the S replace the chip in the third container (red and white chips) permitting the S to see the contents this time.

The above procedure was used to reduce as much as possible undesirable classroom interaction such as repeated requests to go again, and the possible feelings of superiority or inferiority on the part of the Ss who were designated as nonconservers and were to take part in the remainder of the study.

Test Materials and Transformations

The conservation of length pretest consists of two wooden rods (dowel stock) eight inches in length and $7/16$ inches in diameter. The conservation of substance pretest materials are clay balls which are composed of a half pint of glazing compound and a single stick of Klean Klay modeling clay (approximately four ounces). The colors produced are pastel shades of pink, yellow, green, and blue. These four sets consist of five clay balls with weights of approximately one ounce, two ounces, nine ounces, and two of two ounces. The latter two are used for the equivalence conservation of substance test. These clay balls were easily deformed by the Ss reducing the time required for each transformation and permitting the S to attend to the transformation rather than concentrating or at the very least having their attention distracted by the difficulty of the deformation process itself.

The transformations for the conservation of length pre- and posttests were the random presentation of:

1. the displacement of one rod by approximately one fourth of its length.
2. The displacement of one rod by approximately one half of its length.
3. The rotation of one rod by 45 degrees to the reference rod.
4. The rotation of one rod by 90 degrees to the reference rod.

These transformations are performed by the E.

The transformations for the identity and equivalence conservation of substance pre- and posttests are performed by the Ss and consist of the random presentation of the transformation of a ball of clay into a:

1. hot dog
2. ring or circle
3. triangle
4. letter "T".

The specific protocols used for asking the Ss the general question of "same" or "different" are contained in Appendix I for length and Appendix II for substance.

The Training Table

The pretest, symbol training, perception training and posttest sessions use the training table which has a circular top divided into quadrants colored red, green, blue, and yellow. All quadrants are separated by a strip of black plastic electrician's tape and the entire surface is covered with a removable clear plastic cover.

The undersurface of the training table top is fitted with roller bearing casters which rest on a fixed circular bottom also fitted with roller bearing casters which permit the training table top to rotate.

Between each quadrant adhering to the black plastic electrician's tape is a short strip of magnetic tape on which black plastic squares

with metal backing may be placed. The tops of the black plastic squares have white striping in the form of the symbols = (equal to), < (less than), and > (more than).

The training top is mounted with an oak frame enclosed on three sides with orange burlap to screen the tape recorder and other equipment contained on a shelf within the oak frame from the S's view.

The S sits on an adjustable piano stool across the training table from the E. During the pretest and posttest sessions the E operates the tape recorder which picks up the S's responses to questions by a microphone located in a hollow brass fitting at the center of the training table top which provides the central pivot point for rotation of the training top.

Response Classification System

The adequacy or inadequacy of response is based on the following classification of reasons stated by the S. These categories represent a compilation of classifications used in previous studies (Elkind, 1961a; Kooistra, 1964; Rothenberg, 1969; and Wallach et al., 1967).

1. Transformation reversibility. S indicates the shape was changed and it could be returned to the original shape.
2. Original equality of the comparison items. S indicates that the original amounts were equal.
3. Compensation. S indicates reduction of one dimension as

another increases.

4. Addition and subtraction. S indicates nothing was added or taken away.
5. Perceptual. S indicates attention to a single misleading clue.
6. Ambiguous. S gives a limited verbal or so vague an answer that classification in other categories is not possible.
7. Don't know. S indicates verbally that he doesn't know.
8. Magical. S gives unrelated reasons or causes, teleological in nature.

Those answers which are classified in the first four categories are considered to indicate a conserver and the S is dropped from the study. Ss giving answers which are classified in the last four categories are defined as nonconservers of substance and randomly assigned to one of the six interaction groups.

Training for "equal to" (=), "more than" (>), "less than" (<)

The possibility of categorizing an S as a non-conserver because the E does not hold the same concept of words as the S, when such questions as "are they the same?" or "is one now larger?" have been asked, has been pointed out by Smedslund (1969), Griffith, Shantz and Sigel (1967), Lumsden and Kling (1969). To reduce this criticism as

much as possible nine sets, an initial practice set in number, four additional sets in number, and four sets in amount of substance are employed with all Ss who were categorized as non-conservers in the first session pretest on identity and equivalence of conservation of substance. Each set consists of four tasks to train the S in the concepts of "equal to", "greater than", and "less than". The tasks are composed of Lego bases with various items mounted on them. The mathematical symbols and verbal statements are used in conjunction with the training sets.

The nine symbol training sets each consisting of four tasks do not require the concept of conservation. That is, the answers to the questions are nonconservation answers for the task comparisons do not result from transformations such as shape deformation, addition and subtraction, logical multiplication of length and breadth, or transitivity comparisons.

The initial practice set has two main purposes. First, S is introduced to the protocol procedure (see Appendix III) to be used on the other sets. Secondly, the initial practice set has been simplified to obtain maximum probability of S experiencing success. To provide an optimum opportunity for success, misleading perceptual clues are minimized by using regular shaped objects (yellow #2 pencils) familiar to the S, equal spacing of the pencils, equal length of the pencils, and a common white background of the Lego bases on which the pencils are

mounted. The next four number sets employ objects of irregular shape, color, texture, reflectivity, etc. Each set is mounted on four Lego bases of the same color. The last four sets are concerned with amount of substance, which include starfish, Lego blocks in the form of cubes, Lego blocks in the form of rectangular structure surmounted by cubes, and two large plastic cylinders and two smaller plastic cylinders containing mustard seeds and poppy seeds respectively. See Figure 3-1 and Figure 3-2 for the general setup for all symbol training sets.

Generally, it was found that upon the completion of Sets 1, 2, and 3 the S was answering all comparisons on number correctly and the training was shifted to Set #6 (starfish) on amount of substance. If incorrect answers occurred on Set #6 it was usually the result of the S's eagerness to see how rapidly he could get the correct answer and turn the table to the next comparison. If the S had difficulty all sets 7, 8, and 9 were used, but when S evidenced understanding on Set 6 only Set 7 and Set #9 were used. The criterion for comprehension of the symbols was the correct response on the last two amount of substance sets which the S attempted.

Summary of the Symbol Training Session

The initial practice set in number with a minimum of misleading perceptual clues and the subsequent sets in number and amount of

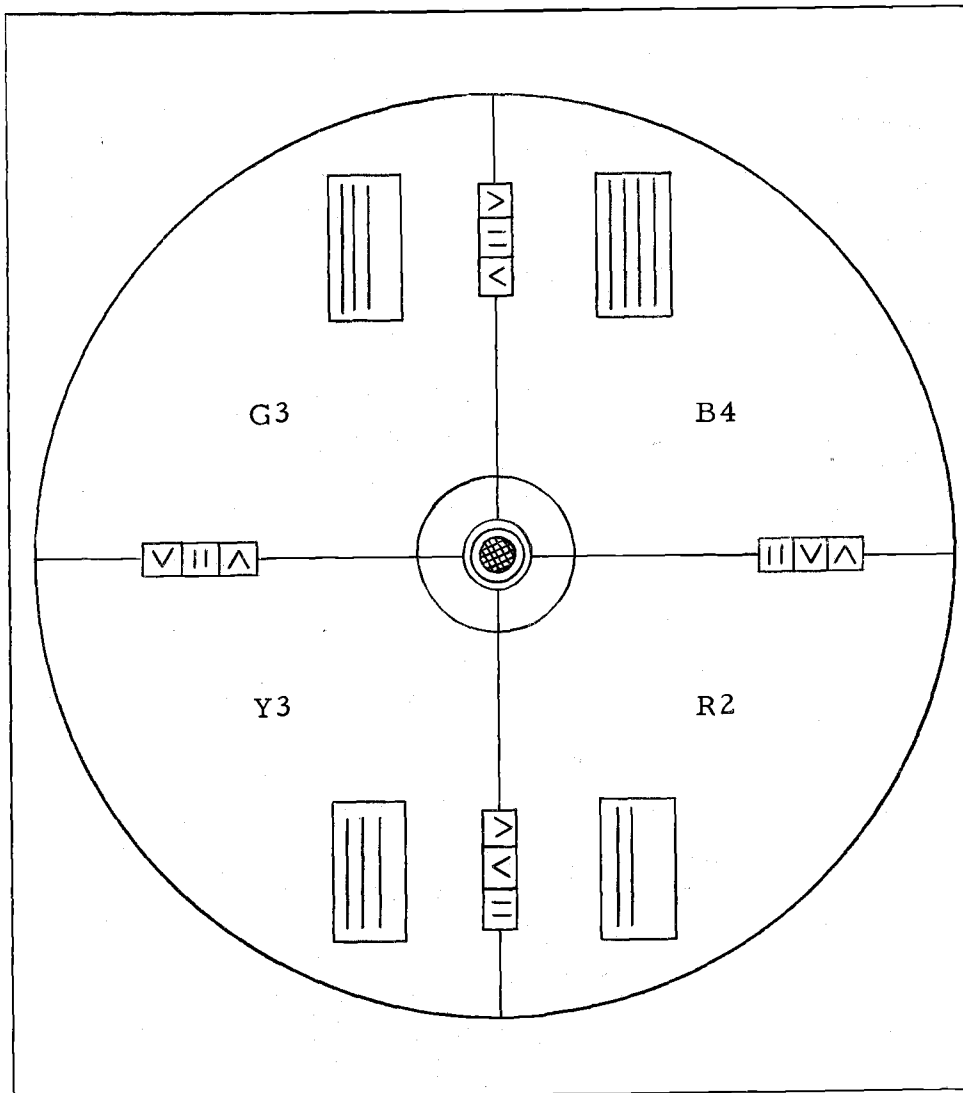


Figure 3-1. Symbol Set #1 with pencils, plastic holder, and magnetic symbols in place. This represents the general set-up for all sets.

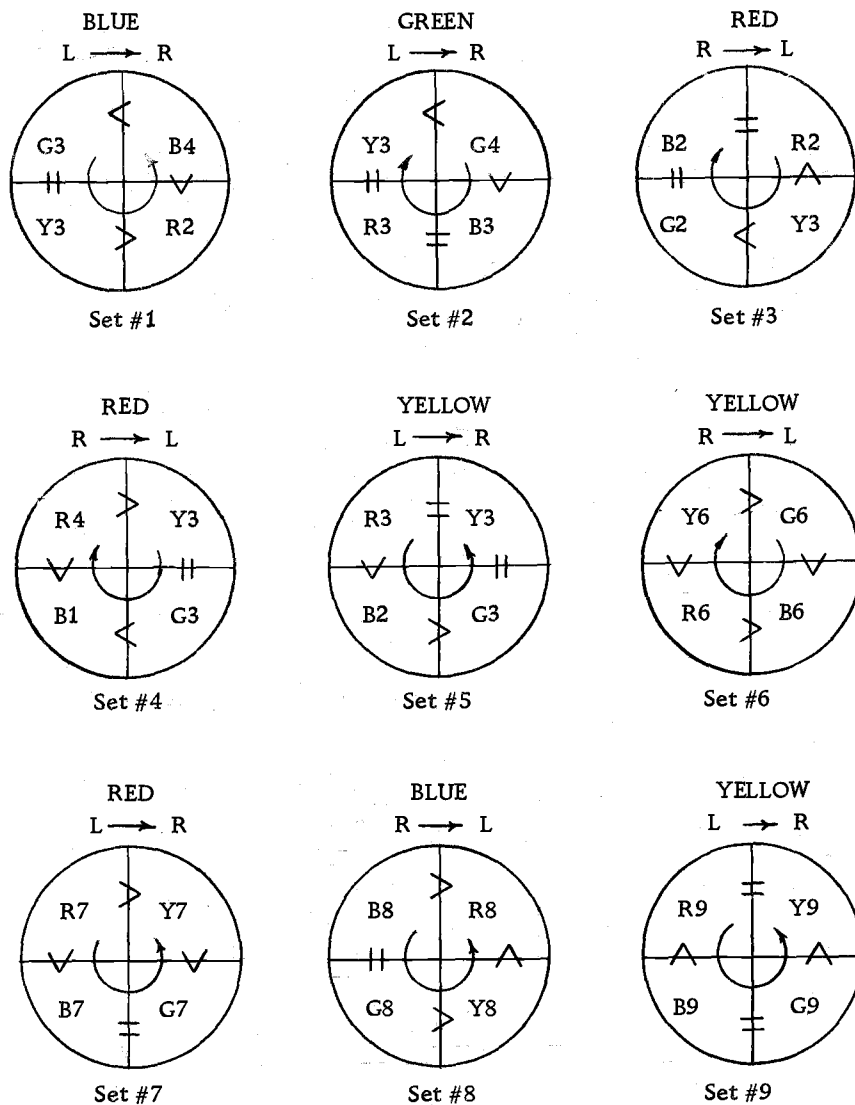


Figure 3-2. Random assignment of color, starting position, direction of rotation and direction of comparison for symbol training. The circles and their four quadrants represent the training table. L → R or R → L indicates the direction of comparison. ⤴ or ⤵ represents the direction of rotation of the training table top. R4, G3, etc. for the first five sets represents the color on which the task item is placed and the number indicates the sum of the items in the task. For sets six through nine the number refers only to the set to which the task belongs. The symbols between the tasks designates the correct symbol response for that comparison.

substance with many misleading perceptual clues are conducted on the circular training board.

The task items are arranged on four colored quadrants with the symbols on the magnetic strips between each quadrant. The training board is free to rotate and the direction of rotation, direction of comparison, starting color, and correct symbols are randomly assigned for each set.

After the initial practice set has been completed S actively engages in the placement of the new set and the replacement of the symbols on the magnetic strips. The activity has two major goals, that of increasing the probability of the S achieving success with the symbols for he must observe the direction of the points on the symbols used for "more than" and "less than" thus, developing a greater familiarity with the symbols. The activity may have a secondary effect in that it demands attention to several details rather than centering on one aspect, which may help in the decentering process so necessary to the acquisition of logical operations. The second major goal is to provide the S with activities that help to maintain a high level of attention.

E records the response of the S on each symbol training set on the student response sheet. The symbol training session continues for a maximum of the nine sets or a maximum time limit of 15 minutes. As soon as the S completes two of the number sets without error, E presents the first of the amount sets. If S then achieves success on

Set #6 and Set #9 (by success is meant that S answered the comparisons as E would answer them) it is inferred that S has a working knowledge of the symbols with respect to number and amount of substance with respect to questions not requiring a conservation response.

If the S does not achieve the operational definition of a working knowledge of the symbols in the 15 minute period the training will be carried over to the third session for a maximum of three quantity sets. If the S does not succeed on the last two of the three sets he is dropped from the study. It was not necessary to drop any S for inability to succeed on the symbol training session.

Extrinsic Motivational Situations

The third session or perceptual training session is initiated by a review of Set #6 of the symbol training session in the use of the symbols =, <, >. At the completion of the review the S is introduced to one of the motivational treatments.

The cognitive dissonance treatment group, CD, and the reward-nonreward treatment group, R, (with specified changes) are developed in the following manner.

E: The S is shown five trinkets by the E and instructed "line-up the trinkets in the order of most liked to least liked".

When the S has completed the arrangement the E checks to make sure he understands the S's order by "is this your

first choice, second choice, etc." When this is completed E says to the S, "We are going to play another game and the rules are that we use your second and third choices (first choice for R group) for the prize(s). If you play the game correctly you will receive your second prize, if you lose the game you will receive your third prize. Do you understand?" The E now has the S repeat the rules.

E: All but the second and third choice (first choice for R group) trinket(s) are (is) removed and the training table with the second and third choices positioned in front of the S with one on either side of the brass rotation housing.

The S in the CD group only is now presented with a series of three tasks which have an outward appearance of being quite easy to perform or answer correctly. Yet, each has a single perceptual feature which is extremely misleading to the S who is still centering on single rather than multiple perceptual clues. The three games which the S is asked to play use (1) a double cone and inclined plane with the obvious perceptual feature of the inclined plane, (2) a glass constant liquid-level tube with the gross perceptual features of different sized tubes, and (3) a center of mass horse and brass ball with the misleading perceptual clue of the brass ball extending in back of the horse and rider. To increase the possibility of misleading clues the E positions the center of mass horse on the support bar in the S's hand so the S must

exert a force to maintain this position. This provides a tactile misleading clue. The specific protocols for the CD treatment are shown in Appendix IV.

The noncognitive dissonance motivational treatment group, NCD, reviews the symbols as did the CD group, but does not employ the trinkets or the CD games used to cause failure on the part of the Ss assigned to CD group. Once the review of the symbols is completed the E introduces the NCD Ss to the perceptual training sequence. At the termination of this session the S is presented with a series of five trinkets, asked to arrange them in the order of most liked to least liked and is given his first choice.

The reward-nonreward treatment group, R, receives the symbol review then is shown a series of five trinkets. E asks the S to arrange them in the order of most liked to least liked. The protocol is the same as the CD group (p. 50-51) with the exception that the S is to receive his first choice if he play the following games (perception training) correctly, and if he does not he will receive nothing. All trinkets are removed with the exception of the S's first choice, and E introduces the perception training.

Summary of the Motivational Groups

All groups review Set #6 of the Symbol Training Session. Upon completion of the review the CD group is shown five trinkets and asked

to arrange them in order of preference. They are then informed of the rules of the game (second choice if they win, third choice if they lose) and the CD games are presented with their misleading perceptual clues. The S loses and is then given a second chance to win his second choice.

The NCD group is introduced to the perception training with no initial motivation in the form of the trinkets.

Those assigned to the R group are shown five trinkets and instructed to arrange them in the sequence of most to least liked. Then they are informed that if the following games are played correctly they will receive their first choice. But if they do not play the games correctly they will receive nothing.

Regardless of how well the Ss perform on the perception training the CD group will receive their second choice, the R group will receive their first choice, and the NCD group upon completion of the perception training are presented with five trinkets and given the same initial instructions concerning the trinkets as the CD and R groups. They are then given their first choice. The result is that all Ss should feel success at the conclusion of the perception training session.

The prizes are placed in envelopes with the S's name on the outside and the S watches as the envelope is sealed with his prize. E informs the S that he will see him one more time and before he goes home from school that day the E will give him his prize. Small

plastic dinosaurs were given to all the Ss who had exhibited conservation on the pretest. These were distributed at the same time as the prizes for the Ss who were classified as nonconservers.

Perception Training in Length and Diameter Devices

The perception training devices consist of four clear plastic holders which support different colored wooden rods (made out of dowel stock) that may be classified as:

1. E-E, equal length and equal diameter (eight rods)
2. E-U, equal length and unequal diameter (seven rods)
3. U-E, unequal length and equal diameter (five rods)
4. U-U, unequal length and unequal diameter (six rods)

The dowels were assigned numbers and then randomly ordered. Next four colors, red, yellow, green, and blue were assigned at random to the 26 dowels.

The last set (U-U) consists of dowels of equal volume with varying lengths and diameters which implies Piaget's grouping of the logical operation of multiplication of width and breadth. As the sets are mixed together it requires the S to attend to multiple perceptual clues such as the length and diameter with the classifications of E-E, E-U, U-E, U-U for successful completion of the task.

It is postulated that direct experience necessitating the simultaneous use of length and diameter to correctly replace the wooden

pegs in their plastic holders will cause the S to decenter and will result in the induction of the logical operation of multiplication of length and breadth which Piaget holds as a necessary condition for development of conservation of substance.

The Logical Operation of Multiplication of
Length and Breadth

Flavell (1963) gives a detailed discussion of the logico-mathematical structures used by Piaget as models to describe cognitive structures. This system developed by Piaget and his associates is derived from group theory and lattice theory, and results in a hybrid theory which is designated as groupings.

These groupings possess attributes of both the group and the lattice. Nine groupings have been defined, but of these Grouping VII is pertinent to this study. Grouping VII involves the one-to-one multiplication of two or more series of asymmetrical relations. For example, the properties of length and width of a piece of clay are represented by A and B respectively, where $\overset{a_1}{\rightarrow}$ indicates an increase in the length, and $b_1\downarrow$ indicates a decrease in the width as the piece of clay is rolled out. The formal description is:

$$(A \overset{a_1}{\rightarrow} A') \times (B b_1\downarrow B') = A \overset{a_1}{\rightarrow} b_1\downarrow B.$$

where A' represents the increase in the length and B' represents the

decrease in the width. Thus as property A varies, property B must vary inversely for the amount of substance to remain constant.

From nonconservation answers given by children to conservation questions it may be inferred that centering on one or another aspect of the transformation has resulted in perceptually misleading clues. For example, a reason given for affirming that an increase in amount of substance had occurred might be, "the hot dog has more clay because it's longer than the ball", or "the ball has more clay than the hot dog because it's fatter". As a result of this centering on a single dimension, it may further be inferred that the child does not possess the logical operation of multiplication of length and width. Piaget (1953, 1959) expresses this view of the child and his inability to conserve as a result of not possessing the above operation.

Halford (1969) used a series of containers which varied in height and breadth, but were of constant volume. This classification system corresponds to the conjunction of heights and breadths. The results of the study were interpreted that children from five years on were capable of constructing such a system employing the logical operation of multiplication of length and width. Bruner (1964), in a multiple ordering study employing beakers which varied in height and breadth and arranged in a matrix which varied in the above dimensions, found that children six and seven years old achieved the capacity to verbally formulate the relations in the matrix. Therefore, the Ss chronological

ages in this study place them well within the minimum limits set in these two studies for the development of compensations or logical multiplication of length and breadth.

Carlson (1969) in a small group study attempted to induce conservation of substance by height, width, and their multiplication, but obtained negative results. The examination of logical thinking and former perceptual modes of responding has been examined by Halpern (1965) in a conservation of weight and transitivity study which concluded that children still manifest perception thinking in certain situations even after logical thinking is evidenced which, in part, might account for Carlson's results. Others such as Smedslund (1966), and Gagné' and Rohwer (1969) take exception to Piaget's position. Here, as in the case of verbal vs nonverbal controversy, the findings are equivocal and open to other interpretations.

The training devices use length and diameter (breadth), and classificatory systems which include the operation of multiplication of length and width as the conjunction of length and width in the U-U set.

Based on other studies the Ss used in this study are chronologically old enough to develop cognitive structures which include the operation of multiplication of length and breadth. These structures are to be developed through the manipulation and successful replacement of the wooden pegs in their respective holders during the activities of the perception training session.

Perception Training Session

Dependent on the motivational level either a motivational treatment situation (CD or R) precedes the perception training or the S is directly introduced to the perception training session with no extrinsic motivational treatment (NCD).

The S has a number of misleading perceptual-clues that used individually will lead to incorrect decisions. Irrelevant to the replacement of the wooden pegs in the holders is the color of the peg. Other features such as the length and the diameter must be considered in conjunction for all wooden pegs in the E-E set interchange with one of the pegs in the E-U set, but do not fit the length requirement. All pegs of the E-E set will fit in five of the seven positions in the U-E holder, but fulfill neither length nor diameter requirements. A number of the pegs in the E-U set seem to interchange within the holder, but as with the U-U set the holders are so constructed that interchange within the holder results in the inability to successfully complete the task. Further, all pegs in the U-E set are interchangeable with one of the pegs in the E-U set, but only one of them possesses the correct length feature. One of the pegs in the E-U set and all the pegs in the U-E set are interchangeable with one of the pegs in the U-U set. Of these, the peg from the E-U set corresponds in both dimensions, while only one of the U-E pegs possesses the proper

classification. Three of the pegs of the U-U set possess one dimension (diameter) which permits their placement in the U-E holder, but not the length dimension.

The simplest of the four classifications, E-E, is introduced first. The S is shown the plastic holder with the wooden pegs in place and told that a series of games are to be played with wooden pegs and holders. The other holders are not in view of the S. The S is instructed to look at the holder and then empty the contents onto the white plastic holder previously used for the symbols. Prior to the S emptying the holder he is asked if he would be able to put the pegs back in the holder if they were dumped out. No S indicated that he would not be able to do this. Upon completion of the E-E holder, S is shown the E-U set with all pegs in place and the same procedure as above is used. The third step involves the E and the S emptying the E-E and E-U sets into the holder with the instructions for the S to replace them in the proper holder. The fourth step introduces the U-E set and is the same as steps one and two. The fifth step involves the emptying of the E-E, E-U, and U-E sets into the plastic holder and requiring the S to replace all the pegs in the proper holders. The sixth step uses the U-U set and is identical to steps one, two, and five. Lastly, all holders are emptied and the S is once again asked to replace all the pegs in the proper holders. This last step involves the replacement of 26 pegs. During any of these stages the E will offer assistance and

encouragement to reduce as much as possible any frustration or sense of failure on the part of the S.

During the perception training session if the S has been assigned to the verbal training group, (VT), he has been asked to verbalize how the pegs are the same or different. If S is unable to verbalize the classifications deriving from the sameness or differences, E will help him to do so. This interaction between the E and the S occurs after step one, four and six, with a summary at the conclusion of the seventh step.

Dimensionality

In Bruner (1964) there is a discussion of the terms "dimensional" and "global" that may be used to classify the language a child uses when asked to classify objects according to size. A verbal spectrum of such terms is given below in Table 3-2.

Table 3-2. Verbal spectrum of size description.

Dimensional Terms	Confounding Terms	Global Terms
*fat and short	fat and big	big
thin and short	skinny and little	little
narrow and long		large
fat and tall	wide and large	small
wide and tall		teeny
skinny and short	small and thin	dinky

*This does not represent an exhaustive list of the terms which may be used by children in size description.

The cognitive functioning of a child that is not attending to the dimensional aspects of size may be inferred from the use of global terms, at least on a verbal level. As a subordinate and perhaps not sufficient condition to the classification of the pegs and hence the development of cognitive structures that result in the child's acquiring the operation of multiplication of length and breadth, it seems the child should exhibit responses classifiable as dimensional with respect to size. To this end the E attempted to have the Ss employ dimensional terms when classifying the pegs in the different sets.

For example, if the S said the pegs are all the same "size", the E would ask what the S meant by "size" to elicit further responses and attention of the S to dimensional characteristics of the pegs. Terms such as: same roundness, different thickness, same tall, different tall, different long, their combinations, and many others were used by the S and employed by the E to attain dimensional verbalization by the S. Roundness, thickness, thinness were found more satisfactory terms to use than "diameter", which seemed to have little meaning to most Ss when describing the breadth of the pegs.

To point out the classification possibilities to the S who employed global and confounded terms, or was unable to verbalize any classification, the E would place his hand over, for example, the E-E set. E would then ask S if he could see how the pegs were the same. If this failed to elicit correct responses (correct for the E) E would

say, "See they (pegs) are all the same length, height, tallness, etc." The plastic holder would then be turned on its side to permit the S to view in a more unitary manner the diameters of the pegs, and the same general format used above was repeated. When both length and diameter had been specified in dimensional terms and used in combination, the S was asked to restate the classification.

The classification questioning was repeated with each new set, and at the conclusion of the seventh step when all 26 pegs were back in place. It is to be specifically noted that in the classification of the U-U set the invariance of volume was not used as the classification criteria. The set was simply classified as increasing in length and decreasing in diameter, or the converse.

Posttests on Identity Conservation of Substance and Equivalence Conservation of Substance

Major changes occur in the identity and equivalence conservations of substance as a result of the symbol training session. The materials remain the same, but certain important changes in the protocol procedures relevant to the S's comprehension of the symbols =, <, and > occur. The S performs the transformation as on the pretest with a different random order of the transformations used in the pretest. After each transformation the question "Is the amount now the same or different?" is replaced by "Pick out the symbol that tells

us about the amount of clay here" (and here for the equivalent portion).

Prior to the transformations the S is told that he is going to play almost the same game as the first time he saw the E. S is then instructed to select from the white plastic holder (the contents are 24 symbols, 16 which can be used to indicate the amount is different, and eight which can be used to indicate the amount is the same), which is in place about the brass rotation point, a sign that would indicate the amounts are (1) different and (2) the same. No student failed to perform this request.

Identity Conservation of Substance Posttest

The posttest of identity uses a single clay ball as did the pretest with random assignments different than the pretest. The specific protocol procedure is the following:

- E: After general procedures are completed as described above, the E gives a ball of clay to the S and says, "I would like you to make this ball of clay into a (one of the transformations of the pretest).
- E: Upon completion of the transformation by the S, says, "Will you pick out the sign (symbol) that tells us about the amount of clay in the (transformed ball) and the ball that you made it from?" When S picks up the symbol, E says, "You say

the amount is the same (different)?" If "the same", the E asks the S, "Why do you think the amount (in the transformed ball) is the same as in the ball?" If "different", E asks the S, "Which one has more, the (transformed ball) or the ball that the (transformed ball) was made from?" E then asks, "Why do you think the ball (transformed ball) has more clay?"

This protocol is repeated for each transformation, and the S's responses and answers are recorded as in the pretest.

Equivalence Conservation of Substance Posttest

The second part of the posttest on conservation of substance is equivalency conservation utilizing a randomly assigned set of colored clay balls, random transformations, and comparison quadrants as did the pretest. The S is shown the five clay balls and instructed to select two clay balls which contain the same, or almost the same, amount of clay. S is then instructed to place the balls of clay on the randomly assigned color areas. Next he is instructed, "to pick out the sign which tells us about the amount of clay here and here (pointing)". If the amounts are equal, E proceeds with the posttest. If unequal, E instructs the S to make the necessary changes to obtain equality. Once S has agreed on the equality of amounts of clay in the two balls, he is asked to perform a transformation. The specific protocol

after equality is obtained is the following:

E: "Now let's make the red (blue, etc.) area's ball into a hot dog (ring, etc.). Good. Now let's pick out the sign that tells us about the amount of clay here and here (pointing). All right, you say it's the same. Why do you think the amounts are the same?" Or if the sign indicates inequality, "All right, you say the hot dog (ball) has more clay than the ball (hot dog). Why do you think the hot dog (ball) has more clay?"

This protocol is repeated for each transformation, and the S's responses and answers are recorded as in the pretest.

The answers to the two sections of the posttest on substance are judged as conservation or nonconservation responses by the same criteria used on the pretest.

Throughout the posttest the E attempts to maintain a friendly, but noncommittal attitude toward all answers given by the Ss.

IV. PRESENTATION AND INTERPRETATION OF THE DATA

The purpose of this study was to compare three levels of motivation and two levels of training (verbal and nonverbal) to determine whether significant differences would be found within the levels of the factors, or between the interactions of the factors.

The Ss were first and second grade students from seven Oregon Public Elementary Schools (Hamilton Creek Elementary School, District 33-C; Crabtree Elementary School, District 110-C; Philomath Elementary School, District 17-J; Lacombe Elementary School, District 73-C; Liberty Elementary School, District 55; Tangent Elementary School, District 26-C; Lincoln Elementary School, District 509-J). Two hundred and eight-two Ss were pretested on identity and equivalence conservation of substance. One hundred and fifty-three Ss were initially classified as nonconservers of substance at the time of the pretest. Attrition reduced this number to a final value of 129 Ss who gave no conservation responses on the pretest. The age range of these Ss was 79 months to 108 months. These 129 Ss were randomly assigned to the interaction groups at the time of their pretest, and subsequently completed all four sessions. The total time for each S was between one hour and one hour and ten minutes with the four sessions taking place within five days.

Preliminary Analyses

Preliminary analysis of variance, used OSU STATISTICAL ANALYSIS PROGRAM LIBRARY, Yates editor (1969, p. OSU-23-1) N-Factor Analysis of Variance, program *NANOVA. F tests were performed to see if age and sex differences existed within the factor levels or the interaction groups. A summary of the data used in computing the preliminary analysis of variance and the hypotheses is given in Table 4-1.

The first of these analyses of variance concerns the average ages, in months, and is shown in Table 4-2. The computed F values for the factor levels and the interaction groups are not significant even at the .10 level. From this it may be inferred that age is not a confounding variable with respect to the interpretation of the study data.

A similar analysis of variance was run using the percentages of nonconserving male and female Ss. This data is presented in Table 4-3. Again the computed F values are not significant at the .10 level, and it is inferred that sex is not a confounding variable in the interpretation of the study data.

Table 4-1. Summary of data used in the study.

Interaction groups	**CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	Total
Summary of sex and age data							
number of male Ss	12	12	11	10	12	14	71
% male Ss	52.2	57.2	57.9	47.6	57.2	58.4	
number of female Ss	11	9	8	11	9	10	58
% female Ss	47.8	42.8	42.1	52.4	42.8	41.6	
Total number of Ss	23	21	19	21	21	24	129
Avg. age in months							
male Ss	92.8	87.6	96.1	89.2	90.1	90.4	90.9
female Ss	90.4	89.6	86.4	89.1	91.6	92.5	90.2
group	91.6	88.4	92	89.1	90.7	91.3	90.5
Pretest: Substance-number of Ss with conservation responses							
	0	0	0	0	0	0	0
Posttest: Substance-number of Ss with conservation responses							
male Ss							
identity	0	0	1	1	1	0	3
equivalence	4	2	1	1	1	1	10
ident. & equiv.	5	5	2	3	5	5	25
total	9	7	4	5	7	6	38
female Ss							
identity	0	0	0	1	3	1	5
equivalence	2	0	1	0	0	0	3
ident. & equiv.	7	3	5	3	1	5	24
total	9	3	6	4	4	6	32
Group total							
identity	0	0	1	2	4	1	8
equivalence	6	2	2	1	1	1	13
ident. & equiv.	12	8	7	6	6	10	49
Total number of Ss giving conservation responses							
	18(5)*	10(11)	10(9)	9(12)	11(10)	12(12)	70(59)
Number of conservation responses							
male Ss							
identity	16	12	6	9	13	17	73
equivalence	33	18	8	16	15	20	110
total	49	30	14	25	28	37	183
female Ss							
identity	26	9	14	11	9	11	80
equivalence	34	9	19	12	4	16	94
total	60	18	33	23	13	27	174
Group							
identity	42	21	20	20	22	28	153
equivalence	67	27	27	28	19	36	204
total	109	48	47	48	41	64	357

*Number in parentheses represents the number of Ss who gave no conservation responses.

**CD-VT: cognitive dissonance-verbal training, CD-NVT: cognitive dissonance-nonverbal training, R-VT: reward-verbal training, R-NVT: reward-nonverbal training, NCD-VT: noncognitive dissonance-verbal training, NCD-NVT: noncognitive dissonance - nonverbal training.

Table 4-2. Analysis of variance of average age, in months, of Ss exhibiting nonconservation of substance on the pretest.

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	Computed F
Sex (S)	4.563	1	4.563	.887*
Motivation (M)	2.412	2	1.206	.235*
Training (T)	6.163	1	6.163	1.20
SM	23.482	2	11.741	2.29
ST	15.870	1	15.870	3.09
MT	6.382	2	3.191	.622
SMT _(error)	10.205	2	5.103	

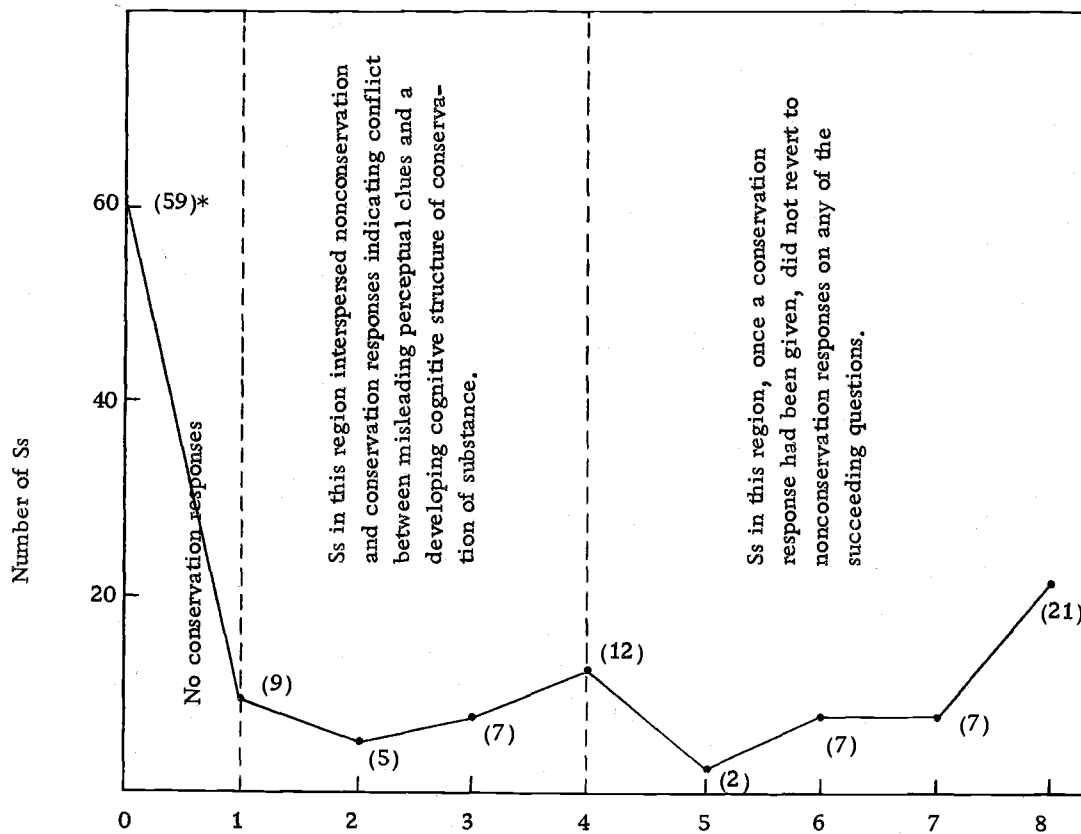
*None significant at the .10 level. $F_{2,2} = 9.00, F_{1,2} = 8.53$.

Table 4-3. Analysis of variance on percent of male and female Ss comprising the nonconservers on substance in the interaction groups.

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	Computed F
Sex (S)	310.08	1	310.08	4.92*
Motivational (M)	0	2	0	0
Training (T)	0	1	0	0
SM	51.88	2	25.94	.408
ST	5.60	1	5.60	.832
MT	0	2	0	0*
SMT	126.92	2	63.46	

*None significant at the .10 level. $F_{2,2} = 9.00, F_{1,2} = 8.53$.

Two additional analyses of variance were performed using age and sex as factors. The basis of these analyses arises from the frequency distribution shown in Graph 4-1. (This graph was drawn from the frequency tabulation of scores shown in Table 4-12).



Total conservation response scores on posttest of conservation of substance

Graph 4-1. Graphical summary of the total frequency responses of the Ss on the eight conservation of substance posttest questions.

*Numbers in parentheses are the Ss giving that number of conservation responses.

From the graph the data may be trichotomized, into Ss with zero conservation responses, one to three conservation responses, and four or more responses. The Ss with four or more conservation responses did not revert to cognitive states, in which misleading perceptual clues dominated, once they started to give conservation responses. The Ss with one to three conservation responses did revert to cognitive states where misleading perceptual clues dominated as inferred from their responses. The Ss in the zero group were totally dominated by misleading perceptual clues.

The data may be dichotomized at the four or greater response frequency on the bases of the Ss not reverting to nonconservation responses once conserving responses had been induced. A comparison may then be made between those Ss giving four or more responses and the interaction groups to see if age or sex is a factor influencing the data.

The first comparison is made between the percentage of male and female Ss with four or more conservation responses on the post-test. The data appears in Table 4-4 and Table 4-5. No significant difference is found on the basis of the computed F value, and it may be inferred that sex is not a confounding variable.

The second analysis of variance dealt with the average age of the Ss giving four or more conservation responses, and the average age of the entire interaction group. Tables 4-6 and 4-7 provide the

Table 4-4. Percentages of male and female Ss giving four or more conservation responses on the identity and equivalence conservation of substance posttest.

	CD		R		NCD	
	male	female	male	female	male	female
VT	46.2	53.8	20.0	80.0	75.0	25.0
NVT	66.6	33.3	57.3	42.7	70.0	30.0

Table 4-5. Analysis of variance on the percentages of male and female Ss giving four or more conservation responses on the identity and equivalence conservation of substance posttest.

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	Computed F
Sex (S)	411.84	1	411.84	.907*
Motivation (M)	.002	2	.001	0*
Training (T)	.001	1	.001	0*
SM	2293.57	2	1146.78	2.53*
ST	927.52	1	927.52	2.03*
MT	.002	2	.001	0*
SMT	906.97	2	453.48	

*Not significant at the .10 level. $F_{1,2} = 8.53$, $F_{2,2} = 9.00$.

Table 4-6. The average age in months of Ss giving four or more conservation responses on the conservation of substance posttest and the interaction group average.

	CD		R		NCD	
	4 or more	group	4 or more	group	4 or more	group
VT	91.5	91.6	88.4	92.0	85.7	90.7
NVT	88.5	88.4	90.1	89.1	93.9	91.3

Table 4-7. Analysis of variance on the average age in months of the Ss giving four or more conservation responses on the conservation of substance posttest.

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	Computed F
Group (G)	2.083	1	2.083	.602*
Motivation (M)	.560	2	.280	.081
Training (T)	.163	1	.163	.047
GM	1.047	2	.523	.151
GT	12.813	1	12.813	3.71*
MT	29.167	2	14.583	4.21*
GMT	6.927	2	3.463	

*Not significant at the .10 level. $F_{1,2} = 8.53$, $F_{2,2} = 9.00$.

data for this analysis. Again no significant differences were found for the average ages and, as before, the variable of age affecting the final data is ruled out.

Analysis of Study Data

The data from the study has been previously presented in Table 4-1. The data summarized therein shows zero conservation responses given by 129 Ss on the pretest of conservation of substance, and 357 conservation responses from 70 Ss on the posttest on conservation of substance.

A chi-square test of independence in two way tables from Wein (1964, p. 582) is used to test the minor null hypothesis that:

H_{minor} : The two classifications (Ss giving nonconservation and Ss giving conservation responses on the pretest and posttest of conservation of substance) are independent.

The contingency table for this test is shown in Table 4-8. The computed chi-square χ^2 statistic (Wein, p. 584) is 96.1 with two degrees of freedom. $\chi^2_{.005}(2) = 10.6$. Therefore, the null hypothesis is rejected and the inference is made that significant changes occurred between the pretest and posttest. These changes are not attributable to age and sex difference as previously shown, but result from the activities engaged in during the four interaction sessions.

Table 4-8. Number of Ss classified according to conservation and nonconservation responses on the pre- and posttest of conservation of substance.

	Pretest	Posttest	Total
Conservation responses	0	70	70
Nonconservation responses	129	59	188
Total	129	129	258

Test of Major Hypotheses

Wilson (1956) presents a distribution-free test of analysis of variance hypotheses using the chi-square statistic, which may be applied to nominal or classificatory data.

The inappropriateness of using more powerful (parametric) statistics on nominal data has been discussed by Sender (1967), and earlier by Siegel (1956, p. 22) who writes that, "measurement at its weakest level exists when numbers or symbols are used simply to classify an object, person, or characteristic". The data of this study essentially falls into this category.

To employ Wilson's method a frequency distribution was compiled as shown in Table 4-9. Next, the observations are divided at approximately the median (M_d). Contingency tables are then constructed as shown in Table 4-10, where n_a is the number of

Table 4-9. Frequency tabulation of scores on the identity, equivalences, and total conservation of substance posttest.

Score		Frequencies for Interaction Groups																				
		Identity Frequencies						Equivalence Frequencies						Total Frequencies						Cum. Freq.		
		CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	Identity	Equiv.	Total
0	male	7	7	7	6	6	9	3	5	7	6	6	8	3	5	6	5	5	8	42	35	32
	female	<u>4</u>	<u>6</u>	<u>4</u>	<u>7</u>	<u>5</u>	<u>4</u>	<u>2</u>	<u>6</u>	<u>3</u>	<u>8</u>	<u>8</u>	<u>5</u>	<u>2</u>	<u>6</u>	<u>3</u>	<u>7</u>	<u>5</u>	<u>4</u>	<u>30</u>	<u>32</u>	<u>27</u>
	total	11	13	11	13	11	13	5	11	10	14	14	13	5	11	9	12	10	12	72	67	59
1	male	0	1	2	2	3	0	0	2	1	0	1	0	0	1	1	1	2	0	8	4	5
	female	<u>0</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>0</u>	<u>1</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>0</u>	<u>8</u>	<u>2</u>	<u>4</u>
	total	0	2	3	3	5	3	0	3	2	0	1	0	0	1	2	2	4	0	16	6	9
2	male	2	2	0	0	1	1	1	2	0	0	3	2	0	2	1	0	0	0	6	8	3
	female	<u>1</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>4</u>	<u>2</u>	<u>2</u>
	total	3	2	1	0	1	3	1	2	1	0	3	3	0	3	1	0	0	1	10	10	5
3	male	0	1	0	1	0	1	1	0	1	0	0	0	1	0	1	0	2	0	3	2	4
	female	<u>0</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>0</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>	<u>1</u>	<u>4</u>	<u>4</u>	<u>3</u>
	total	0	1	1	3	1	1	3	0	1	0	0	2	1	0	2	0	3	1	7	6	7
4	male	3	1	1	1	2	3	7	3	1	4	2	4	4	1	0	1	1	1	12	21	8
	female	<u>6</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>7</u>	<u>2</u>	<u>4</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>2</u>	<u>12</u>	<u>19</u>	<u>4</u>
	total	9	3	3	2	3	4	14	5	5	7	3	6	6	1	0	1	1	3	24	40	12
5	male													0	0	0	1	0	0			1
	female													<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>			<u>1</u>
														1	0	0	1	0	0			2

Continued on next page

Table 4-9 Continued.

		Frequencies for Interaction Groups																		Cum. Freq.		
		Identity Frequencies						Equivalence Frequencies						Total Frequencies								
		CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	CD-VT	CD-NVT	R-VT	R-NVT	NCD-VT	NCD-NVT	Identity	Equiv.	Total
6	male													1	1	0	0	0	3			
	female													0	0	1	0	0	1			
	total													<u>1</u>	<u>1</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>4</u>			<u>5</u>
7	male													0	1	0	1	0	1			
	female													1	0	1	2	0	0			
	total													<u>1</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>0</u>	<u>1</u>			<u>4</u>
8	male													3	1	1	1	2	1			
	female													5	2	2	1	1	1			
	total													<u>8</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>2</u>			<u>9</u>
Total	male	12	12	10	10	12	14	12	12	10	10	12	14	12	12	10	10	12	14			
	female	11	9	9	11	9	10	11	9	9	11	9	10	11	9	9	11	9	10			
	total	23	21	19	21	21	24	23	21	19	21	21	24	23	21	19	21	21	24	129	129	129

Table 4-10. Frequency contingency tables for conservation responses made by the Ss on the posttest of conservation of substance.

	Total Frequencies				Identity Frequencies				Equivalence Frequencies			
	CD	R	NCD	f_{ai}	CD	R	NCD	f_{ai}	CD	R	NCD	f_{ai}
VT	18	8	7	33	12	8	10	30	18	9	7	34
NVT	9	7	12	28	8	8	11	27	10	7	11	28
f_{aj}	27	15	19	61	20	16	21	57	28	16	18	62
				$=n_a$				$=n_a$				$=n_a$
				129				129				129
				$=n$				$=n$				$=n$

	Total Frequencies				Identity Frequencies				Equivalence Frequencies			
	CD	R	NCD	f_{bi}	CD	R	NCD	f_{bi}	CD	R	NCD	f_{bi}
VT	5	11	14	30	11	11	11	33	5	10	14	29
NVT	12	14	12	38	13	13	13	39	11	14	13	38
f_{bj}	17	25	26	68	24	24	24	72	16	24	27	67
				$=n_b$				$=n_b$				$=n_b$

Md = 2	Md = 1	Md = 1
--------	--------	--------

observations greater than or equal to the median, n_b is the number of observations less than the median, f_{ij}^a represents the number of observations greater than or equal to the median in the cell in row i and column j , and f_{ij}^b represents the number of observations less than the median in the cell in row i and column j .

The general expression for the total chi-square value, χ_T^2 is:

$$(1) \chi_T^2 = \sum_{ij} \left[\frac{(f_{ij}^a - n_{ij}^a/n)^2}{n_{ij}^a/n} + \frac{(f_{ij}^b - n_{ij}^b/n)^2}{n_{ij}^b/n} \right],$$

for the chi-square value of the row effects, χ_R^2 is:

$$(2) \chi_R^2 = \sum_i \left[\frac{(f_{i\cdot}^a - n_{i\cdot}^a/n)^2}{n_{i\cdot}^a/n} + \frac{(f_{i\cdot}^b - n_{i\cdot}^b/n)^2}{n_{i\cdot}^b/n} \right],$$

for the chi-square value of the column effects, χ_C^2 is:

$$(3) \chi_C^2 = \sum_j \left[\frac{(f_{\cdot j}^a - n_{\cdot j}^a/n)^2}{n_{\cdot j}^a/n} + \frac{(f_{\cdot j}^b - n_{\cdot j}^b/n)^2}{n_{\cdot j}^b/n} \right],$$

and for the chi-square value of the interaction effects, χ_I^2 is:

$$(4) \chi_I^2 = \chi_T^2 - \chi_R^2 - \chi_C^2$$

where:

$$n_{ij} = f_{ij}^a + f_{ij}^b$$

$$n_a = \sum_i \sum_j f_{ij}^a$$

$$n_b = \sum_i \sum_j f_{ij}^b$$

$$n_{i.} = \sum_j n_{ij}$$

$$n_{.j} = \sum_i n_{ij}$$

and χ_T^2 has $(rc-1)$ degrees of freedom, χ_R^2 has $(r-1)$ degrees of freedom, χ_C^2 has $(c-1)$ degrees of freedom, and χ_I^2 has $(c-1)(r-1)$ degrees of freedom.

The four equations, (1), (2), (3), (4), are used in the analysis of the frequency data in Table 4-9 and the contingency tables in Table 4-10. The hypotheses to be tested using these four equations are:

H_{01} : There will be no difference between the three motivational groups in their performance on the conservation of substance posttest.

H_{02} : There will be no difference between the two training groups in their performance on the conservation of substance posttest.

H_{03} : There will be no interaction between subject membership in both independent variable groups and their performance on the conservation of substance posttest.

The computed chi-square values for the total frequency scores, identity frequency scores, and equivalence frequency scores are summarized in Table 4-11.

Table 4-11. Summarization of the computed chi-square values obtained from Wilson's equations when applied to the frequency data.

Frequency	Computed χ^2			
	χ_T^2	χ_R^2	χ_C^2	χ_I^2
Total score	12.46	1.12	5.54*	5.8*
Identity score	2.06	-	-	-
Equivalence score	13.30	1.80	6.79 [#]	4.71**
*Significant beyond the .10 level			$\chi^2_{2(.10)}(2)$	4.61
[#] Significant beyond the .05 level			$\chi^2_{(.05)}(2)$	5.99
**Significant at the .10 level				

Based on Table 4-11 the hypothesis:

H_{01} : There will be no difference between the three motivational groups in their performance on the conservation of substance posttest.

was rejected beyond the .10 level of significance for the Total Score. That is, there is evidence that the CD treatment group was more effective in increasing the frequency of conservation responses on the posttest.

For the Identity Score no major hypothesis was rejected due to an insufficient χ_T^2 value.

H_{01} was rejected beyond the .05 level for the Equivalence Score. Sufficient evidence was present to infer the CD group was more effective in increasing the frequency of conservation responses

on the conservation of substance posttest.

The hypothesis:

H_{02} : There will be no difference between the two training groups in their performance on the conservation of substance posttest.

was not rejected for the Total Score, Identity Score, or the Equivalence Score frequencies. That is, there was no evidence to infer verbal training (rule statement for classification of the perception training devices) was more efficacious than nonverbal training (no rule statements for the classification of the perception training devices).

Finally, the hypothesis:

H_{03} : There will be no interaction between subject membership in both independent variable groups and their performance on the conservation of substance posttest.

is rejected for the Total Score and the Equivalence Score frequencies.

The chi-square value χ^2_I for the Equivalence Score just exceeds the .10 level of significance while the chi-square value χ^2_I for the Total Score is significant beyond the .10 level. Thus, interaction exists between the motivational and training factors. The major values to this interaction are contributed by the a_{11}^f and b_{11}^f cells for the Total Score frequencies. The respective values of these cells are 4.63 and 4.17 and constitute 70.7% of the total value for the chi-square

effects total, χ^2_T . These are the two cells for the CD-VT interaction group and their values represent the evidence for singling them out as the source of variation which resulted in the rejection of hypothesis H_{03} .

Summary

Based on the preliminary analyses of variance sex and age are not confounding variables in interpreting the results of the study. This was true for the initial interaction groups as well as the dichotomized data resulting from grouping the Ss with four or more conservation responses on the substance posttest.

A test of independence was computed on the classification of the Ss on the pretest and the posttest with respect to conservation of substance responses.

The null hypothesis:

H_{minor} : The two classifications (number Ss giving nonconservation responses and the number of Ss giving conservation responses on the pretest and the posttest of conservation of substance) are independent.

The null hypothesis was rejected beyond the .005 level. Therefore, it was inferred that significant changes occurred during the four interaction sessions resulting in an increase of Ss giving conservation responses that is greater than chance occurrence.

The major hypotheses H_{01} was rejected at the .10 level for the Total Score frequencies and at the .05 level for the Equivalence Score frequencies. In both instances the major contributing term was the CD group cells.

H_{02} was accepted for all score frequencies as there was insufficient evidence to infer that training had any effect on the acquisition of conservation of substance.

H_{03} was rejected at .10 level for the Equivalence Score and beyond the .10 level for the Total Score frequencies. The major sources contributing to this difference were the CD-VT cells. Thus, cognitive dissonance when coupled with verbal training is more effective than the other interaction groups.

The Identity Score frequencies produced no chi-square values that approached significance.

Overall the CD group performed statistically better than the R or NCD motivation groups, and the CD-VT interaction group statistically outperformed the other interaction groups in the study.

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to determine by a 3 x 2 factorial design whether conservation of substance could be effectively acquired through the independent motivational factor involving cognitive dissonance, reward-nonreward, and noncognitive dissonance levels, and the independent training factor variable with a verbal and a nonverbal level.

The experimental Ss were children with chronological ages that placed them in Piaget's Concrete Operational Stage, but who were classified as nonconservers of substance on the pretest. These Ss were obtained from seven public elementary schools in Oregon, and those operationally classified as nonconservers were seen individually by the E a total of four times, each interaction session lasting ten to fifteen minutes. Two hundred and eight-two Ss were pretested on conservation of substance and length. From this group 129 Ss classified as nonconservers were randomly assigned to the six statistical interaction groups and completed all phases of the training.

The first interaction session included the pretests on conservation of length, and identity and equivalence conservation of substance. All Ss were given symbol training in number (cardinal) and amount of substance. The question and response format did not use conservation

type questions. No S was unable to perform to the operational definition for manipulating the symbols more than, less than, and equal to.

The third session was initiated by one of three motivational level protocols. Ss in the CD and R groups were shown five items and requested to rank them according to most liked to least liked. If the Ss were assigned to the CD group a series of arranged games were played and the Ss lost their second choice. A second opportunity was then offered introducing the perceptual training aspect of the session. The Ss assigned to the R condition were instructed to arrange the trinkets, and then informed if they played the ensuing games (perceptual training devices) correctly they would receive their first choice. The NCD level was introduced directly to the perception training devices, and only at the conclusion of the session were they given the opportunity to order the trinkets and then instructed they would receive their first choice.

The perception training devices used in the third interaction session were clear plastic holders containing dowel stock that had four different classifications (equal length and equal diameter, equal length and unequal diameter, unequal length and equal diameter, and unequal length and unequal diameter). During this time those Ss in the verbal training interaction group were questioned concerning the classification of the dowel stock in each plastic holder and given the classification if they were unable to do so. The nonverbal training

group did not receive this instruction.

The fourth session, the posttest on identity and equivalence conservation of substance, differed from the pretest protocol by requiring the S to "pick out the sign which tells us about the amount of clay here and here", rather than being asked if the "amount of clay here and here was the same or different". The answers to the above question, and the request for a reason why the S thought as he did, were tape recorded.

Conclusions

Preliminary analyses of variance produced no significant difference in the age and sex of the interaction groups. Nor was age and sex found to be a factor for those Ss giving four or more conservation responses on the conservation of substance posttest. From these analyses it is inferred that sex and age are not confounding variables in the interpretation of the study data.

An initial test of independence was performed with the χ^2 value significant beyond the .005 level. This was interpreted that significant changes had occurred as a result of the interaction sessions inducing conservation responses in the experimental Ss. The calculations were based on zero Ss having conservation responses on the substance pretest, and 70 Ss out of the 129 Ss giving one or more responses on the posttest of conservation of substance.

A chi-square analysis of variance, after Wilson (1956), was applied to the Identity, Equivalence, and Total Frequency Scores of the conservation response data. From these calculations the Identity Score Frequency produced no significant results. For the Total Score Frequency and the Equivalence Score Frequency there was evidence beyond the .10 and .05 levels, respectively, that motivational level effects were significant. Thus, the hypothesis:

H_{01} : There will be no difference between the three motivational groups in their performance on the conservation of substance posttest.

was rejected and the inference made that the CD group treatment was more effective in acquisition of conservation responses than the NCD or the R groups.

The major hypothesis involving interaction produced significant results at the .10 level for the Equivalence Score Frequency and beyond the .10 level for the Total Score Frequency. The hypothesis:

H_{03} : There will be no interaction between subject membership of both independent variable groups and their performance on the conservation of substance posttest.

was rejected and the inference drawn that CD-VT interaction group provided a significantly better environment for inducing conservation responses.

The hypothesis:

H₀₂: There will be no difference between the two training groups in their performance on the conservation of substance posttest.

was not rejected, there being insufficient evidence for training effects in the study.

Recommendations

Based on the data gathered in this study, the investigator recommends that:

1. A more detailed study be conducted using the independent motivational factor with cognitive dissonance and noncognitive dissonance levels versus the age and sex of the Ss as this latter aspect is confounded in the present study.
2. A study be conducted using the verbal and nonverbal levels as the independent variable with additional training to insure the S's ability to apply dimensional terms rather than mixed or global terms to classification systems as used in the present study.
3. The use of simple perceptual training materials as developed in the present study combined with cognitive dissonance and verbal training to provide operationally defined nonconservers of substance activities conducive to the acquisition of conservation of substance.

4. As the result of the pretest on length and substance conservation where approximately 61% of the first graders and 47% of the second graders exhibited nonconservation responses, it is recommended that testing be performed to ascertain the Ss who are nonconservers. These data should then be actively used in the building of science activities which do not require conservation application at the onset.
5. Further study is needed to delineate and clarify the conception of identity and equivalence conservation. The present study, in the form of identity and equivalence testing used, does not support this division.
6. The reevaluation or rethinking of the educational goal of present training devices used in the elementary schools. For example, what results obtain from the use of C-rods by children who are conservers and children who are non-conservers of length. Are the results those anticipated?
7. Materials and strategies developed to achieve conservation should not demand of the child a "correct" adult response. That is the child should be permitted to make these discoveries for himself rather than being given the "correct" answer.

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APPENDICES

APPENDIX I

PROTOCOL PROCEDURE FOR PRE- AND POSTTEST
OF CONSERVATION OF LENGTH

The Protocol Procedure for the Conservation
of Length Pretest and Posttest

E: The two wooden rods (sticks) are handed to the S. E asks the S "Are the two rods (sticks) 'the same' or 'different' in length?" The answer must be "the same" length before proceeding. Rewording by E, moving of the sticks, or any other suggestion made by the S short of cutting one of the sticks is performed. If equality can not be achieved the transformations are performed with E keeping in mind the inequality expressed by the S.

E: All right, watch closely, I'm going to move this rod (pointing). One of the transformations is performed, for example, the rod is displaced one fourth of its length. The S is asked, "Are the sticks 'the same' or 'different' in length?" If the answer is "different", E asks, "Which one is longer?" "Why do you think so?" If the answer is "the same", E asks, "Why do you think so?"

This procedure is used for all the transformations on the conservation of length pre- and posttests, with the responses to the question "are the sticks 'the same' or 'different' in length recorded on the student information sheet.

APPENDIX II

PROTOCOL PROCEDURE FOR PRETEST ON
CONSERVATION OF SUBSTANCE

The Protocol for the Conservation of
Substance Identity Pretest

E: A clay ball is placed in front of the S who is then instructed by the E to pick it up and "see if it squishes easily". The S is then asked if he has ever felt clay like that before. Here the purpose is to put the S at ease. E now says, "Can you roll the clay back into ball? Good."

E: We're going to play a game and I would like you to make this ball of clay into a hot dog (ring, letter "T", triangle). Then I'm going to ask you some questions about the hot dog, don't you think that will be fun?" After S completes the transformation E asks, "Is the amount of clay in the hot dog (ring, letter "T", triangle) 'the same' or 'different' than the amount of clay that you made the hot dog (ring, letter "T", triangle) from?" If the answer is 'the same', E asks, "Why do you think so?" If the answer is 'different', E asks, "Which one has more clay?" "Why do you think so?"

The same procedure is used for the remaining transformations with the responses to the 'same or different' question recorded on the student data sheet and the reasons for those responses recorded on the tape recorder.

The Protocol for the Conservation of
Substance Equivalence Pretest

- E: The S is presented with five clay balls and E asks the S to look carefully at these clay balls and choose two balls that contain the same or almost the same amount of clay. When S has done this the E removes the other three clay balls and if necessary has the S perform any operation required to achieve equality. S must agree to the equality of the two clay balls before proceeding.
- E: All right let's pretend that this ball of clay is the red (green, blue, yellow) area's and this ball of clay is the yellow (green, red, blue) area's. Do the red and blue areas have the same amount of clay? If not, readjust to obtain equality.
- E: All right will you roll the red area's (pointing) ball of clay into a hot dog (ring, letter "T", triangle). After S completes the transformation E asks, "Is the amount of clay here and here (pointing to the two areas) 'the same' or 'different'?" If the answer is 'the same', E asks, "Why do you think so?" If the answer is 'different', E asks, "Which one has more 'the hot dog (ring, letter "T", triangle) or the ball of clay?" "Why do you think so?"

This same procedure is used for the remaining transformations with the responses to the 'same or different' question recorded on the

student data sheet and the reasons for those response recorded on the
tape recorder.

APPENDIX III

PROTOCOL PROCEDURE FOR SYMBOL TRAINING

Protocol Procedure for the Symbols

The training table is arranged with Set #1 as shown in Figure 3-1 with the tasks G3, B4, R2, and Y3. The three symbols are in place on the magnetic strip between each of the color section. As the table is turned the tasks are moved by the S to positions directly in front of him to provide maximum opportunity for observing and making the necessary observations to remove the incorrect symbols which are placed in a white plastic container that fits about the brass housing that contains the microphone. The specific procedures are as follows:

- E: "We are going to play a game with these symbols". (The word designation was dependent on whether the S has been introduced to these symbols in arithmetic and whether the word "sign" or "symbol" has been used by the teacher.)
- "Have you ever seen these symbols (signs) before?" Regardless of the answer E says, "I'll show you how to play the game using these symbols (signs)."
- E: "I'm going to ask you some questions so that we can play the game. Okay?" Are the number of pencils here (pointing to B4 and G3) and here 'the same' or 'different' in number?" The answer must be different, if not have S count the number of pencils.
- E: "Which has 'more' pencils?" If S hesitates or gives the

incorrect answer ask, "Which has the 'less' number of pencils, which has the 'greater' number of pencils, which has the 'fewer' number of pencils," and back to the original question, "Which has 'more' pencils?" The correct response is always reinforced by "good, that's right".

E: "You have two rules to remember: (1) when the number of things are the same (equal) you use the "equal" (same) symbol (sign). It is the one with the two straight lines. Will you point to the equal sign?" If correct reinforce, if incorrect restate rule and point again to the equal sign. "The second rule is: the point of the sign is always toward the less or fewer number of things. Will you point to the two signs which are pointed?" If incorrect point to the signs for S and have him repeat the gesture. S is then asked to restate the rules after E has given them.

E: "Now the game is to take off the two signs that do not tell us about the number of things here and here (pointing), and place them in this white holder (pointing to the white plastic holder at the center of the training table). All right let's see if we can do the first one. Okay?"

E: "Are the number of pencils here and here (pointing) the same or different in number?" If different, say, "Take off the equal sign and place it in the white holder." If same,

have the S count the pencils, and reask the question. "Now which of the two signs tell us about the number of pencils? Remember the correct symbol always points toward the number which is less or fewer." If S removes the wrong symbol have him replace it and remove the other symbol while restating the rule. S is then instructed to repeat the rule.

E: Rotate the training table telling S that he may help. E says, "Let's see if you can do this one by yourself." If S hesitates, or seems unable to do the task repeat the preceding section. The E repeats the same protocol procedures for each task comparison until the S is able to do the task himself.

The same protocols are used for the ensuing sets with the only changes being: (a) that S helps place the task items on the training table in subsequent sets, and (b) S helps to replace the symbols on the magnetic strips. When the training with the number sets is complete E introduces the quantity sets using the following protocol.

E: The S helps E place Set #6 (starfish) on the training table. E then asks, "What symbol would you use to tell about the number of starfish here, here, here, and here?" (pointing in turn to each task item). If equal (same) say, "Let's change the game and use the signs (symbols) to tell us about

the amount of starfish here and here (pointing)". If not equal point out to S. Then ask, "Is the amount here and here (pointing) the same or different?" and then proceed with the protocol procedures outlined above if necessary.

APPENDIX IV

PROTOCOL PROCEDURE FOR COGNITIVE
DISSONANCE MOTIVATIONAL TREATMENTS

Specific Protocol for the Cognitive Dissonance
Motivational Treatment

- E: The S is now presented with the double cone and inclined plane with the double cone at the midpoint of the inclined plane. E asks S, "to look closely and tell E which way the double cone will roll". E then releases the double cone. S then is permitted to release the double cone to see that E did not give it a push in the direction contrary to the one stated by E.
- E: The S is presented with the second of the games and again asked to look closely at the "glass tubes which are all connected at the bottom". This is stressed again by E repeating the question, "Do you see that all the glass tubes are connected at the bottom?" E now points to a white plastic pin strip about the largest tube and tells the S, "See the white stripe, I'm going to pour green colored water into this tube until it comes up to this line. I want you to take this pencil and mark on these other tubes where the water will come when I have poured it to this line". This statement is repeated until the S comprehends and marks the other three tubes. E then pours the green colored water into the large marked tube until it is up to the white stripe. At this point if S has given two incorrect responses, E informs him that

he has lost the game and hence his second choice. Otherwise, E proceeds to the third game.

E: The S is told "You are doing very well, here is the next game". E presents the center of gravity horse and rider with a support stand. E places the center of gravity horse and rider on the narrow plastic support. E without releasing the horse asks the S to "take hold of the horse, but be careful and don't let him fall. Now what will happen when you let go of the horse?" If the S responds incorrectly at this time E informs him that he has lost the game and therefore his second choice. Otherwise, E proceeds to the "Soma Cube".

E: The S is again informed that "You are doing very well indeed and if you play this last game correctly you will win your second choice". S is shown the "Soma Cube" assembled and a three minute egg timer with the instruction, "You are to take the puzzle apart then start the timer. You will have three minutes to put the puzzle back together." Failure at this point results in E informing S that he has lost the game and his second choice. The second choice is moved a little further away from the S with the comment that "It is a nice prize and I really wish you had won it". E now removes the games which have been left on the training table. This

procedure is to give the S time to regard the loss of the second choice. Approximately 15 to 20 seconds elapse and E says, "You did so well before that I really would like to see you win that nice prize; would you like another chance to win it by playing an easier game?" No S refused this offer. If this had not been the case the S would have been dropped from the study. The acceptance of the offer to play another game initiates the perceptual training session.