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NUMBER TRAINING TECHNIQUES AND THEIR EFFECTS ON DIFFERENT POPULATIONS. FINAL REPORT.

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DESCRIPTORS- *NUMBER CONCEPTS, *CONCEPT FORMATION, *TEACHING PROGRAMS, TEACHING TECHNIQUES, PRESCHOOL CHILDREN, PRESCHOOL EDUCATION, POST TESTING, PRETESTING, *CONCEPT TEACHING, *CONSERVATION (CONCEPT), COGNITIVE DEVELOPMENT, LONG ISLAND, NEW YORK, PIAGET,

PIAGET HAS PROPOSED THAT THE CONCEPT OF NUMBER IS PREDICATED ON THE CONCEPT OF CONSERVATION OF SUBSTANCE--THAT IS, THE CONCEPT THAT THE AMOUNT OR NUMBER REMAINS THE SAME DESPITE SPATIAL REARRANGEMENTS. BECAUSE OF THE CURRENT EMPHASIS ON REVISION OF MATHEMATICS CURRICULUM AND OF THE APPARENT VALUE OF NUMBER TRAINING TO PRESCHOOL DISADVANTAGED CHILDREN, THIS STUDY WAS CREATED TO INVESTIGATE (1) WHETHER TRAINING PROGRAMS CAN EFFECTIVELY TEACH 3- TO 6-YEAR-OLD CHILDREN THE CONCEPT OF CONSERVATION OF SUBSTANCE, AND (2) IF SO, WHETHER SOME TRAINING PROCEDURES ARE MORE EFFECTIVE WITH CERTAIN POPULATIONS THAN OTHER PROCEDURES. ACCORDING TO PIAGET, TRAINING PROGRAMS ALONE ARE NOT SUFFICIENT TO TEACH CHILDREN THE CONSERVATION CONCEPT. ALL OF THE ACTIVITIES OF A CHILD, HIS GRADUAL INTELLECTUAL DEVELOPMENT, LEAD TO THE ACQUISITION OF THE CONCEPT. TO INVESTIGATE PIAGET'S IDEAS ON THE FORMATION OF THE CONCEPT OF CONSERVATION OF SUBSTANCE, 416 CHILDREN OF AGES THREE TO SIX AND OF VARIED SOCIOECONOMIC LEVELS WERE ADMINISTERED ONE OF FOUR TRAINING PROCEDURES AFTER A PRETEST. THE FOUR TRAINING PROCEDURES USED WERE (1) SMEDSLUND'S COGNITIVE CONFLICT METHOD, (2) SIGEL'S MULTIPLE CLASSIFICATION METHOD, (3) BEILIN'S VERBAL RULE INSTRUCTION METHOD, AND (4) BRUNER'S LANGUAGE ACTIVATION METHOD. AT THREE TIME INTERVALS AFTER THIS TRAINING PERIOD, POSTTESTS WERE ADMINISTERED TO ASCERTAIN THE QUALITY AND EXTENT OF THE CHILD'S LEARNING OF THE CONCEPT. THE CONCLUSION REACHED FROM COMPARING THE TEST RESULTS FOR THE FOUR TRAINING GROUPS TO THE RESULTS FROM A CONTROL GROUP WAS THAT THE TRAINING PROCEDURES, ALONE, WERE INEFFECTIVE, REGARDLESS OF THE POPULATION TYPE, IN TEACHING THE CHILDREN THE CONSERVATION-OF-SUBSTANCE CONCEPT. (WD)

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Egon Mermelstein - Edwina Meyer

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The task of preparing the final report was lightened by Mrs. Jean Morris, who did the typing and served as secretary for the project.

Egon Mermelstein

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Number Training Techniques and their Effects on Different Populations

Increased emphasis on revision of mathematics curriculum, coupled with the apparent beneficial value of pre-school number training for disadvantaged children, has led to a controversy over the most appropriate time to teach the concept of number. Accordingly, a renewed interest in Piaget's experiments on the child's conception of number has been demonstrated.

Piaget declares that the concept of number is predicated on the concept of conservation of substance. The attainment of the concept of conservation of substance enables the child to recognize that the "amount" or "number" remains the same despite spatial rearrangements. The following description is an example of a Piagetian conservation of substance task. A child is confronted with two identical containers of liquid. After the child is convinced that the amount of liquid in both is the same, the contents from one of the containers is poured into three other containers. The child is then questioned as to the equality of the amount of liquid in the three containers and the amount in the original container. A child is said to have attained the concept of conservation of substance when he recognizes that the amounts are the same and he is able to explain why. On the other hand, if the child responds that the amounts are different, then it is said that he has not attained the concept of conservation of substance.

Piaget maintains that specific training or teaching plays little or no role in the acquisition of the concept. He suggests that the child attains the concept of conservation of substance by interaction with his "total" environment. On the other hand, the advocates of early intervention programs (Project Head Start, etc.) maintain that such programs improve the child's intellectual development. They suggest that this intellectual development will result in a corresponding improvement in academic achievement and school success. More specifically, they contend that the acceleration of number development, a dimension of intellectual development, has obvious implications for success in later number work. In support of this contention, Almy et al (1966, p.84) have demonstrated that children who conserve at an early age do better in beginning reading and arithmetic than those children who are non-conservers.

Reissman (1962) further maintains that although the goals

of various pre-school programs or training procedures may be the same, some approaches to improving intellectual development (number development) may be more successful than others. Specifically, he suggests that those training procedures which rely more on concrete, manipulative and non-verbal techniques may be more effective with disadvantaged children than those which do not.

It appears that the work of Beilin (1966), Bruner (1964), Sigel (1966) and Smedslund (1961) would tend to support the advocates of early intervention programs. Each has devised training procedures to induce or teach the concept of conservation of substance, a pre-number concept. Interestingly, however, none of these investigators suggest that a particular kind of training procedure may be more successful with one population in contrast to another population. These researchers seem to imply that one can induce or teach the concept of conservation to the child regardless of the population from which they come.

Because there are theoretical reasons for believing that the concept of conservation of substance is relevant to a child's number development, the question first arises as to whether or not children can be taught the concept of conservation of substance. And secondly, whether some training procedures are more effective with certain populations than other training procedures.

Theory:

To answer the first question, perhaps an examination of Piagetian theory is appropriate. Acqusition of the concept of conservation of substance implies a modification of the child's intellectual structure. According to Piaget, this modification occurs as a consequence of all of the child's activity in contrast to specific short term training. All of the child's activity refers to two kinds of experiences: physical and logical mathematical. Whereas physical experiences provide knowledge through the child's manipulation of the objects (i.e., playing with chips), logical mathematical experiences result in knowledge acquired as a consequence of manipulation (i.e., awareness that two rows of six chips each have the same number despite rearrangement).

It is apparent that physical experiences may be attained through short-term exposure and are a necessary condition for the acquisition of concepts. However, logical-mathematical experiences require a longer period of time to attain because the child must now be concerned not simply with the objects but rather with the relationships between the objects.

Awareness of such relationships requires an intellectual structure which has developed beyond the ego-centric mode of cognition. Such development allows the child to move from dependence solely on a perceptual field of physical experience to the ability to adopt several perspectives or points of view. The ability to coordinate several points of view or position constitutes logical-mathematical experiences. Logical-mathematical experiences are derived primarily from social interaction which provides the cognitive conflict necessary for the development of concepts.

Accordingly, recognition of the relationships of the logical-mathematical experiences cannot be acquired or induced in short term training as socialization is needed. Such training which appears to provide primarily physical experience violates the dual nature of the Piagetian notion of "all" the child's activity. With reference to conservation, purely physical experiences leads to what Flavell calls the hollow core of conservation.

Obviously, if these relationships are acquired over a perperiod of time, the contention that training on a few specific tasks for a short period would induce conservation is as specious as the argument that specific training on a limited number of tasks from I.Q. tests would improve intelligence. Increased performance on these I.Q. tests as a consequence of training does not imply increased intelligence. So, too, specific training on conservation tasks does not guarantee the acquisition of the concept of conservation.

Since Piagetian theory suggests that training procedures in general are not effective, the answer to the question whether certain procedures are more effective with different populations appears evident. Piagetian theory makes no claim that one kind of social interaction is superior to another. Consequently, this implies that regardless of the population, training will be unsuccessful.

Although Piagetian theory and specific training are incompatible, some of the literature reported below, however, suggests that intellectual structures can be modified over a relatively short period of time. The major problem of this study, then, is to provide more evidence on the question of whether or not mental structures can be modified over a relatively short period of time utilizing a diverse population.

Related Literature:

The literature appears equivocal as to the feasibility of inducing the concept of conservation. Consistent with Piagetian

theory, Wohlwill (1960) has been unsuccessful in inducing conservation of number utilizing a sample of middle class kindergarten children. Similarly, Beilin and Franklin (1962), utilizing a sample of middle class first graders, have been unsuccessful in inducing conservation of area. Prager (1966), using her class of Project Head Start preschoolers, was unable to induce conservation of substance. Mermelstein et al (1967), using a sample of low-middle income kindergarten children was unable to induce the concept of conservation employing a variety of procedures. These studies suggest that regardless of the kind of conservation that one tries to induce with diverse populations, that in general, such training is not successful.

In testing for the presence of conservation, rather than attempting to induce it, Mermelstein (1967) found no difference in performance on conservation of substance tasks between those children who had formal schooling and those who did not in Prince Edward County, Virginia. Similarly, Goodenow's (1966) study in Hong Kong and Price-Williams (1961) study with African bush children indicate no difference in performance on conservation of substance tasks between children who had and those who had not received formal schooling. Summarizing the the other existing literature on conservation, Almy et al (1966, p. 34) states that on the whole, that the bulk of replication studies supports the notion that the child's ability to conserve quantity and number is arrived at gradually.

These studies suggest that "specific" training in general, formal schooling in particular do not necessarily modify intellectual structures. And more specifically, they imply that such training may be of limited utility over a wide range of populations.

On the other hand, although Smedslund reports negative results in attempting to induce conservation of weight, in another study (1961c) in which he introduces the idea of cognitive conflict, Smedslund appears to have had some success in inducing the concept of conservation of substance. Similarly, Gruen (1965), employing a cognitive conflict technique, induced the concept of conservation of substance. Bruner (1964) also reports success in inducing the concept of conservation of substance but by a language activation technique rather than a cognitive conflict technique. Utilizing a somewhat similar technique to cognitive conflict, Wallach and Sprott (1964) and Wallach et al(1967) induced number conservation by reversibility training. Employing still another technique, verbal rule instruction, Beilin (1966) reports some success in inducing conservation of length. And finally, Roeper and Sigel (1966), employing a technique which incorporates aspects of the techniques described above,

report success in inducing the concept of conservation of substance. In particular, Roeper and Sigel (1966) maintain that training in multiple labeling, multiple classification, multiple relations, and reversibility will facilitate acquisition of the concept of conservation of substance.

It should be noted that the studies which claim success in inducing conservation, all utilized middle class populations in contrast to the wide range of populations utilized by the researchers in conservation studies described as unsuccessful.

But these investigators who have claimed success in inducing conservation with middle class children have suggested the possibility of inducing various kinds of conservation by a variety of training techniques. Because of the equivocal results reported, an analysis of the various training techniques seems appropriate.

If specific training does not make a difference, the present investigators feel that Smedslund's cognitive conflict theory provides the greatest promise for success because of its similarity to Piaget's theory of adaptation. Gruen (1966) supports such a contention when he suggests that Smedslund's definition of conservation appears more congruent with Piaget's definition than with Bruner's definition.

Piaget's discussion in strategies to decrease egocentric thought in the child provides a good illustration of the similarity of the cognitive conflict position and Piaget's adaptation position. Egocentric thought characterized by the inability to adopt another person's view, permeates children's thinking during the pre-operational stage. In order to reduce the egocentrism in the child, Piaget suggests socialization with other children in the form of play. In essence, Piaget suggests the confrontation of different viewpoints. As a result, the child's intellectual structures become modified to permit him to take another's point of view.

The conflicting viewpoints which come about in child play reflect a similarity between Piaget's adaptation position and Smedslund's cognitive conflict position. Smedslund's cognitive conflict position involves, as an illustration, a child first recognizing the numerical equality of two rows of chips over several training sessions; then on a subsequent session having the experimenter deform one row. At this time, the child is confronted with two conflicting viewpoints: numerical equality and apparent numerical inequality. To account for the apparent disparity this conflict results in a modification of the intellectual structure. Thus, it appears that cognitive conflict and apdatation are similar concepts to explain a change in intellectual structures.

Because of the similarities of the two concepts, one may be tempted to state that this contradicts Piaget's training position. But all that is claimed is that the cognitive conflict position embodied in Smedslund's training procedure is similar to Piaget's position of adaptation.

Furthermore, both adaptation and cognitive conflict processes employ the disequilibrium-equilibrium model. In both instances, after the confrontation the child moves toward a state of temporary equilibrium from a state of disequilibrium. Similarities in the two processes would suggest that training procedures based on a cognitive conflict position may be in part successful.

Play with its confrontation of different viewpoints (cognitive conflict) does not appear to have priority among one population in contrast to another. Consequently, to the extent that Piagetian adaptation theory and cognitive conflict theory are compatible, different population are of no consequence. A translation of Smedslund's theoretical position into practice as well as translations of Bruner's, Beilin's, and Sigel's theoretical positions are described in the procedure section.

In addition to Smedslund, Sigel, Beilin, and Bruner constitute a representative sample of the various theoretical positions described in the literature which claim success in training on conservation.

Whereas Smedslund's theoretical position is consistent with Piaget, Sigel, Beilin, and Bruner present arguments for inducing conservation which are either wholly inconsistent or only partially consistent with Piagetian theory.

Sigel's argument is predicated on the assumption that one must base the learning of complex structure on simpler structures. He claims that acqusition of conservation of substance follows the acquisition of simpler structures such as multiple labeling, multiple classification, multiple relations, and reversibility. More specifically, he maintains that training in multiple labeling, multiple classification, multiple relations, and reversibility, in that order, should facilitate the acquisition of conservation.

Although Sigel's procedures indeed are necessary conditions for conservation of substance, they are not, however, sufficient conditions. Sigel's training assumes, that once the prerequisites for conservation have been met, the concept of conservation necessarily has been attained. Sigel further assumes that because the material is presented in a prescribed manner, the child will assimilate the material in the corresponding order. Such a

claim is not consistent with Piagetian theory; for if the child constructs his reality, it does not necessarily follow that he will assimilate the material in the same manner presented.

Whereas Sigel's training originated in part from Piagetian theory, Beilin's training procedure appears to directly violate Piagetian theory. Beilin's training procedure, verbal rule instruction, provides the child with a statement of a rule to be applied to the problem in each instance of an unsuccessful trial response on a conservation task.

The use of a rule in a training technique appears inconsistent with Piagetian theory. To begin with, the egocentric nature of the child's thought seriously hampers his ability to adopt another point of view. Secondly, the syncretic nature of the child's mental structure with its behavioral manifestations of juxtaposition prevents him from accurately perceiving the rule. Further, Mermelstein and Shulman's (1967) research indicated that children under nine years of age perceive only the gist of questions or the events of the questions. It follows from this that two sentences which stress "amount", for example, but in very different ways, will be perceived as similar by the child. Thus, the child will not truly understand a "specific" rule. Therefore, since induction of conservation in this technique is based on the understanding of a specific rule, this casts doubt on the verbal rule procedure that Beilin presents.

Similarly, Bruner's contentions on language training also appear to be inconsistent with Piagetian theory. Bruner's training position is predicated on the assumption that focusing on the linguistic aspect of a situation will decrease the strength of the perceptual cues. The resulting structure then is a function of the language activated. This differs markedly from Piagetian theory in that Piaget believes that the mental structure precedes language development.

Examination of the theoretical positions underlying the training techniques of Beilin, Bruner, Sigel, and Smedslund suggests that Smedslund's training technique is most consistent with Piagetian theory. This suggests that, although Smedslund's research was limited to a middle class population, the training would be successful with any population. And further, that even though the Bruner, the Beilin, and the Sigel techniques employ more verbal content than the Smedslund, the contention that the advantaged child should do better on these training procedures than the disadvantaged child is ill founded.

Although advantaged children manifest language facility superior to disadvantaged children, the impact of the difference

is seriously questioned at this stage of development. In other words, all children tend to rely more on concrete-manipulative experiences rather than linguistic experiences. And further, because of the syncretic characteristic of child thought, it is questionable whether their greater language facility can be appropriately harnessed to assist in the acquisition of the concept. For according to Piaget, without the concept, the language facility cannot be appropriately directed. Consequently, it is contended that the particular population is of no consequence in an examination of the acquisition of the concept of conservation.

To recapitulate then, because the concept of conservation derives from Piagetian theory and further because the rationale for the Sigel, the Beilin, and the Bruner training are judged to be inconsistent with Piagetian theory, it is hypothesized that these training procedures would not be effective with a diverse population. On the other hand, because of the greater congruence of Smedslund's position to Piagetian theory it is hypothesized that such training would be more effective than the other three training procedures.

Objectives:

Accordingly then, the objectives of this study were to ascertain whether various training procedures can influence the acquisition of the concept of conservation of substance. In view of these objectives, the following hypotheses were forwarded:

1. A significant difference exists in the performance on conservation tasks between children who had cognitive conflict training and those who had no training.

2. No significant difference exists in the performance on conservation tasks between children who had multiple classification training and those who had no training.

3. No significant difference exists in the performance on conservation tasks between children who had verbal rule instruction training and those who had no training.

4. No significant difference exists in the performance on conservation tasks between children who had language activation training and those who had no training.

Method

Subjects:

In order to assess the effects of various training procedures with different populations on the attainment of the

concept of conservation, three samples of children between 3 - 6 years of age from the Long Island, New York area were selected for this study: 96 children (5 classes) from the Hofstra University Nursery School 3½ - 5 years of age, 100 children (5 classes) from the Westbury School System, L.I. Project Head Start (4 - 5 years of age), and 220 kindergarten children (8 classes) from Uniondale School District, L.I. (5 - 6 years of age). This particular population includes six year olds because the writings of Piaget indicate that children of this age generally have not attained the concept of conservation of substance. Children as young as 3 years, 6 months were selected to determine if effective training can be started at this age level.

Within each of the 13 classes approximately equal numbers of males and females were randomly assigned to the five conditions (4 training and 1 control). Half of the classes within each school district were then randomly selected for the pre-test.

Experimenters:

Seven graduate sssistants (two male and five female) were taught all the training procedures and given practice in using them. The graduate assistants were randomly assigned, three to the Westbury School System and four to the Uniondale School District. Within both school districts each graduate assistant was randomly assigned two classes which he trained, with the exception of one who was assigned one class in Westbury and one class at the Hofstra University Nursery School.

In the Hofstra Nursery School the assistant teachers who were also graduate students had three sessions learning training techniques. Working in conjunction with two research assistants, the assistant teachers did the training.

After the training, the graduate assistants were randomly assigned to different populations for Post-test I. In addition, since the post-tests necessitated the use of graduate assistants in pairs, they were randomly assigned to one another. On Post-test II and Post-test III, the pairs of graduate assistants were randomly re-assigned and a conscious effort was made to place them with a population they had neither trained nor post-tested previously.

Description of Pre-test:

The pre-test task employed the collapsible box and 20 poker chips. As the experimenter set up 10 chips down one side of the top of the box, the subject simultaneously set up 10

chips on the other side in one-to-one correspondence with those of the experimenter. After the experimenter verbally established that he and the child had equal numbers of chips, one row of chips was collapsed by the experimenter, and hence, perceptually distorted. The subject was then asked whether the chips on the collapsed side were still the same amount as those on the stationary side. If the subject's response was positive and his explanation indicated understanding, that is, he realized the chips merely changed position, he was scored as a conserver. A subject who answered affirmatively without an adequate explanation, or a subject who answered negatively was scored as a non-conserver.

Training Apparatus:

Red, white and blue poker chips ware used in all four training conditions in order to minimize task variability. A wooden box 16 3/4" long x 6 1/2" wide x 6 1/4" deep was employed in the pre-test, cognitive conflict training, multiple classification training and verbal rule instruction training. The top of the box was divided lengthwise with one side remaining stationary and the other side broken crosswise and hinged together at its center. A rod was attached to the hinge through an opening in the side of the box. The rod could be moved downward through a slit in the side of the box, enabling the center portion of the broken side to collapse to the center of the box. This box lent itself to perceptual distortion of a one-to-one correspondence numerical arrangement.

In the fourth training condition, language activation, three square wooden boxes, each with two transparent parallel sides, were employed. Two of the wooden boxes were identical in size, 4 1/2" x 4 1/2" x 6", while the third box was the same height (6"), but wider (7" x 7").

The apparatus for all the training techniques conformed in principle to the requirements of each training procedure. Although the present study may not be regarded as an explicit replication of either the Smedslund, Bruner, Sigel or Beilin training technique, it is felt to be a fair test of the principles which underlie these techniques. In other words, while there were some slight variations in procedure to make the experimental tasks comparable, the basic assumptions stated by these investigators were not violated.

Description of the Training Procedures:

The four training conditions, cognitive conflict (Smedslund), multiple classification (Sigel), verbal rule instruction (Beilin), and language activation (Bruner), each began with free play and were followed by eight training sessions, two

times a week for approximately ten minutes. The first training session was devoted entirely to introducing the subjects to the red, white and blue poker chips and allowing them to manipulate them in any way they chose. In each of the successive eight training sessions for the first two minutes the subjects were permitted to play with the chips. The remainder of each session was devoted to formal training.

Cognitive Conflict - Smedslund:

The cognitive conflict training involved the collapsible box and twenty poker chips. Following the free play, where the subjects were allowed to manipulate the chips, the group of subjects received ten chips of one color and the experimenter received ten chips of the same color. In the first session, red chips were employed, in the second session blue, and in the third white, with this color order being maintained throughout the remaining sessions. As the experimenter placed a chip on one side of the top of the box, the subjects simultaneously placed another chip next to it until all twenty chips were in one-to-one correspondence. Following the placement of each pair of chips, the experimenter asked the subjects questions such as "Are there the same amount of chips on both sides of the box? Do the children have the same amount as the teacher? How do you know? If the subjects did not realize the equality of the two rows of chips, they were encouraged to count the chips. After five sessions of setting up the chips in one-to-one correspondence, the task was altered. In the next three sessions, after the chips were similarly set up in one-to-one correspondence and the sameness of the two rows of chips was established, the experimenter moved the switch hinged on the side of the box and one of the rows of chips fell to the center of the collapsed side. The subjects were asked, "Are there still the same amount of chips on both sides?"

Multiple Classification - Sigel:

The multiple classification training also involved twenty poker chips and a collapsible box. Free play with the chips preceded the formal training. The training was divided into four phases: 1. multiple labelling, 2. multiple classification, 3. multiple relations and 4. reversibility. For the first four training sessions, one training session was devoted to each phase while each of the remaining four training sessions encompassed all four phases.

In multiple labelling training the experimenter initiated discussion which elicited the naming of the poker chips in a variety of ways; i.e., a poker chip can also be a checker or toy money. This "naming" was clarified for the subject by the experimenter suggesting that a person could have many names, i.e., mother, teacher, woman, wife, etc..

In multiple classification training, the experimenter initiated discussion which elicited from the subjects the common properties of the chips; i.e., all the chips have color, shape, purpose, texture and size.

In the multiple relations training, the experimenter initiated discussion which led the subjects to understand that a chip can be two things at the same time. That is, a chip can have a color and shape at the same time. The question that was posed is, "Can you think of two things this poker chip can be at the same time?". Since a different colored poker chip was used at each session, three relationships were established: (1) round and red, (2) round and blue, and (3) round and white.

In the reversibility training the collaspible box and twenty chips were employed. The experimenter and the subjects set up the chips in one-to-one correspondence so that the subjects could see the sameness of the two rows of chips. After the subjects responded positively to the question, "Are there the same amount of chips on both sides?", the experimenter collapsed one side of the box. Again the subjects were asked whether there were the same amount of chips on both sides of the box and why. An informal explanation to establish the equivalence of both sides was then provided by the experimenter.

It should be pointed out that although superficial similarities exist between Smedslund's cognitive conflict training and the reversibility training of Sigel, they differ in that in the Sigel reversibility training the equality of the rows of chips and the subsequent collapse of one row was accomplished in one training session whereas Smedslund's training procedure had four training sessions on the equality of chips prior to collapse of one row of chips. In addition, the Sigel technique provided explanations for the equivalence of both rows after the deformation, whereas the Smedslund technique did not.

Verbal Rule Instruction - Beilin:

The verbal rule instruction, as well as multiple classification, employed the collapsible box and twenty chips. Following the free play the group of subjects and the experimenter each received five chips of one color. As in the cognitive conflict training, the chips were set up in one-to-one correspondence and their equivalence established. But in contrast to the cognitive conflict training, the experimenter immediately collapsed one side of the box and asked whether there are the same amount of chips on both sides. Regardless of the positive or negative responses of the subjects, the experimenter said the following rule while manipulating the box accordingly: "Now I am moving them. See, they are standing in a different place, but there are as many chips as before. They only look different. See, I can put them back just the way they were. So you see, there are still the same amount as before because I did not add any chips or take away any chips. I only moved them". In the next session, twenty chips of the same color

used in the preceding session were used, and in subsequent sessions, for each color, first ten and then twenty chips were used.

Language Activation - Bruner:

The language activation training involved three wooden boxes, a screen and twenty chips. Each of the boxes had two transparent parallel sides. Two of them were identical, while the third was the same height but wider than the others. Following the free play, using a one-to-one correspondence technique, the subjects filled one box with ten poker chips while the experimenter simultaneously filled the other identical box. The third box was placed with the two filled boxes behind the screen so that only their tops could be seen. The experimenter poured the chips from one of the filled boxes into the third unfilled, wider box. The child was asked whether there were the same amount of chips in the newly filled box as in the remaining previously filled box. It was expected that the subject would say that they were the same. The screen was removed and the subject was again asked whether the boxes held the same amount. Since one box was wider, the chips in it were spread out, and were therefore perceptually different from those in the narrower box. This training procedure was repeated for each of the three color chips in subsequent sessions.

Description of the Post-tests

In order to test the effects of the various training treatments, two non-verbal tasks in which the law of conservation of substance was violated, and two standard Piagetian tests of conservation were employed.

Tasks

1. Non-verbal Continuous Task:

The first non-verbal experiment, the magic experiment for conservation of a continuous substance, consisted of first allowing each child to satisfy himself that two 150 ml. beakers contained the same quantity of liquid. The contents of one of the beakers was then poured into a 1000 ml. jar which it apparently filled. The child's gestures and reactions were noted. Gestures of surprise, puzzlement, smile, "wow" were scored at stage three, presence of conservation, whereas absence of observable change in behavior were scored at stage one, absence of conservation. The illusion was created by surreptitiously opening a valve connecting the empty 1000 ml. jar to one which was full and hidden behind the screen. The experimenter controlled the rate at which the visible jar filled.

2. Non-verbal Discrete Task:

The second non-verbal magic experiment, for a discontinuous substance, again violated the law in conservation; it assumed that a child who had attained the concept would recognize the violation. Two seemingly identical wooden boxes, one with a false bottom, and 26 marbles were employed. Each child was told to put eight marbles into the wooden box with the false bottom, one by one, as the experimenter put eight marbles into the second wooden box, one by one. Under the false bottom in the child's box was an additional ten marbles. The experimenter poured the contents of the two wooden boxes into two separate containers. When the contents of the child's box were poured, a latch released the additional ten marbles. The child's reactions and comments to the marbles in the containers were noted. Scoring of these responses was similar to those for the first post-test for continuous substance.

3. Verbal Piagetian Task:

The third task was a typical Piagetian verbal test for conservation of discrete substance. Each child was told to put eight gumballs into a 150 ml. beaker, one-by-one, at the same time the experimenter put eight gumballs into another 150 ml. beaker. The contents of one beaker were then poured into a 50 ml. graduated cylinder, while the contents of the second beaker were poured into a 600 ml. beaker. The child was then asked whether the quantities in each were the same. Whatever his response, he was asked why he thought so.

4. Verbal Piagetian Task:

Two rows of chips (10 in each row) were set in one-to-one correspondence. Their equality was not established. One of the rows was then changed into a circle and the child was asked whether there are the same amount or number of chips in the row as in the circle. He was then asked why he thought so.

The circle of chips was then deformed into a "clump" of chips next to the row and, pointing to the appropriate group of chips, the child was again asked whether the amount or number of chips are the same. He was then asked why he thought so.

Scoring of Responses:

On both the non-verbal tests, the criteria for conserving responses are described above. On both the verbal Piagetian tasks, the responses were assessed as follows: If the child said that the quantity was the same amount and gave the correct reason (i.e., they were the same as before), this was categorized at stage 3. If the reason was correct but the response was wrong this was categorized at stage 1. If the subject said that the amount was the same, but he did not know why, he was scored at stage 2.

The reliability of the scoring procedures was assessed by nine raters, three raters for approximately 130 subjects, on post-test I and post-test II. On both post-tests the percent of agreement among the groups of three raters was above 90%.

Testing of Subjects:

Each subject was tested individually. The sequence in which the tasks were presented were counter-balanced to control for order effects.

The subjects in the four training conditions and the one control condition were tested three weeks*, two and a half months and five months after the last training session.

Design:

A 2 x5 x3 analysis of variance design was utilized to test the overall effect of training. Within the design the variables of Testing, Type of Training, and Time were balanced. In addition three 5 x 3 analysis of variance designs were employed to examine the interaction of Type of Training and Time for each of the three populations.

* Subjects had complete training prior to Winter Recess.

(a) 2 x 5 x 3 Analysis of Variance Design

	Treatment		Time T1	T2	T3
Pretest	Treat A Control	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat B Verbal Rule Ins.	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat C Multiple Class.	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat D Language Act.	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat E Cognitive Conflict	Subjects 1			
		2			
		3			
		⋮			
		30			
Non-Pretest	Treat A Control	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat B Verbal Rule Ins.	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat C Multiple Class.	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat D Language Act.	Subjects 1			
		2			
		3			
		⋮			
		30			
	Treat E Cognitive Conflict	Subjects 1			
		2			
		3			
		⋮			
		30			

(b) 5 x 3 Analysis of Variance Design

	Treatment		Time T1	T2	T3
Populations	Treat A Control	Subjects 1			
		2			
		3			
		:			
		n			
	Treat B Verbal Rule Ins.	Subjects 1			
		2			
		3			
		:			
		n			
	Treat C Multiple Class.	Subjects 1			
		2			
		3			
		:			
		n			
	Treat D Language Act.	Subjects 1			
		2			
		3			
		:			
		n			
	Treat E Cognitive Conflict	Subjects 1			
		2			
		3			
		:			
		n			

Results

In order to test hypotheses described in the procedure section Dunnett's multiple comparison was used. To examine the effects of pretesting, time, treatments and the interactions relevant to the four hypotheses a 2 x 5 x 3 analysis of variance design for partly correlated data was employed. A 5 x 3 analysis of variance design was employed to examine the effects of time and treatment for the specific populations described in the procedure section. To compare verbal and non-verbal tests of conservation the binomial test was employed.

In order to test the hypotheses, a form of multiple comparison was necessary. Accordingly, Dunnett's procedure (1955) in which each of a number of different treatments is compared with the control was used. The assumption was that if there were a significant difference between the control mean and the specific treatment means, the treatment mean would be significantly higher. Since Dunnett's test requires that all scores be independent of each other, the average score for each subject across all three post tests was used in this analysis. To calculate whether or not the differences between the control mean and treatment means were significantly different at .05 level, the T values for one-sided comparisons for a joint confidence coefficient were used (Dunnett p. 1117). For significance, the difference between the control mean and the respective treatments must be $\geq$ .2011.* Table 1 presents the results of the obtained differences between each treatment mean and the control mean.

Table 1

Obtained Differences Between Each Treatment Mean and The Control

	Control				
Beilin	$X_b - X_a$	1.6028	- 1.6398	=	-.0370 **
Sigel	$X_c - X_a$	1.6568	- 1.6398	=	.0170 **
Bruner	$X_d - X_a$	1.6905	- 1.6398	=	.0507 **
Smedslund	$X_e - X_a$	1.7498	- 1.6398	=	.1100 **

* See appendix for calculation
** Not significant at the .05 level

The results indicate that none of the differences are significant at the .05 level. Hence the cognitive conflict hypothesis is rejected whereas the other hypotheses are supported. It should be mentioned, however, that the difference between Smedslund and the control group was the largest.

Further credibility to the obtained results above is given by an examination of Dunnett's table (p. 1116). In this table the appropriate "n" for a given number of treatments can be determined to give a probability of .80 of correctly selecting a superior treatment, (if there is one), which is greater than the control by various amounts. For 4 treatment groups to obtain a power a .80 and identify a treatment differing from the control group by one S.D., Dunnett suggests an "n" of 20 per group. To distinguish a difference of 3/4 S.D. the "n" must increase to 36 and to find a difference of 1/2 S.D., an "n" of 80 per group is required. The "n" for the control group and the treatments group is .60. Since "n" = 60 lies between 36 and 80, therefore the probability is .80 is that we can correctly select a superior treatment differing from the control between 1/2 and 3/4 S.D.. In other words, if in fact there were a difference between 1/2 and 3/4, the likelihood is .80 of being able to detect such a difference.

Table 2 presents the results of the overall effect of training, pretesting and time and the interactions relevant to the four hypotheses.

Table 2

2 x 5 x 3 Analysis of Variance Table

Source	S.S.	D.F.	M.S.	F
Pre or no Pre	.0316	1	.0316	- n.s. *
Treatment	2.2302	4	.5576	- n.s. *
Pre & Treatment	1.7061	4	.4265	- n.s. *
Error (a)	226.7817	290	.7820	-
Times	8.3872	2	4.1936	25.0364 p. <.005**
Pre x Times	.5645	2	.2823	1.6854 n.s. *
Treatment x Times	1.6848	8	.2106	1.2573 n.s. *
Pre x Treatment x Times	1.5241	8	.1905	1.1373 n.s. *
Error (b)	97.1482	580	.1675	
Total	340.0584	899		

* at the .05 level
** significant at the .05 level

As can be seen from the analysis of variance table* in Table 2, the overall main effects of treatment, pretesting are not significant at the .05 level whereas the main effect of time is significant at the .05 level. The first order interactions of pretesting and time, treatments and time, pretesting and treatments, and the second order interaction, pretesting and time and treatment are not significant. Thus we may assume that the non-significant interactions do not offer rival hypotheses or explanations to the hypotheses forwarded. Moreover, the non-significant main effects of treatment offer supporting evidence for the overall lack of success of training procedures.

The main effect of time was significant. The overall means of T1, T2 and T3 were 1.53, 1.72 and 1.75 respectively. These results indicate that with time improvement in conservation occurs. This result is consistent with the contention that acquisition of conservation is a function of factors other than training. Clearly, because of the non-significant interaction of time with treatments, etc., these do not contribute to the significant main effect of time.

Tables 3, 4 and 5 report the results relevant to the particular populations; Westbury School System, Uniondale School District and Hofstra University Nursery School, respectively.

Table 3

5 x 3 Analysis of Variance Table for Data Obtained in Westbury

Source	S.S.	D.F.	M.S.	F
Groups	1.1731	4	.2933	- n.s.**
Res (a)	23.4918	60	.3915	-
Times	2.1920	2	1.0906	12.67p. <.005***
Group x Times	.3896	8	.0487	- n.s.**
Res (b)	10.3789	120	.0865	-
Total	37.6254	194		

n = 65
Total number scores 195

*A complete description of the analysis of variance procedure used is given in Edwards, Experimental Design in Psych. Research, Chapter 14.

**Not significant at the .05 level.

***Significant at the .05 level.

Table 4

5 x 3 Anlaysis of Variance Table for Data Obtained in Uniondale

Source	S.S.	D.F.	M.S.	F	
Groups	5.1108	4	1.2777	1.5866	n.s. *
Res (a)	161.0542	200	.8053		
Times	3.6281	2	1.8140	14.2610	p. < .005**
Gp x Times	1.2640	8	.1580	1.2421	n.s. *
Res (b)	50.8906	400	.1272		
Total	221.9577	614			

n = 205 subjects
Total number scores 615

Table 5

5 x 3 Analysis of Variance Table for Data obtained at Hofstra

Source	S.S.	D.F.	M.S.	F	
Groups	.3588	4	.0897	-	n.s. *
Res (a)	17.4574	55	.3174		
Times	7.4730	2	3.7365	22.71	p. < .005**
Gp x Times	1.3159	8	.1645	-	n.s. *
Res (b)	18.2087	110	.1655		
Total	44.8138	179			

n = 60 subjects
Total number scores 180

* at the .05 level
** significant at the .05 level

The results described in these tables are identical to the ones described in Table 2. It appears then, that these results indicate that the treatment effects are not significant, that they are independent of the population: and that no significant time treatment interaction exists. As in Table 2, a significant time effect is indicated with all three populations. This significant time effect suggests factors other than training are operating in the acquisition of the concept with each of the populations. It should be emphasized again that these populations not only differ in age but in socio-economic class as well.

Because children who are trained may have the concept but not be able to verbalize it, a comparison of verbal and non-verbal tests of conservation seemed appropriate. Table 6 and 7 reports the results of a comparison of a Verbal Task IV with each of the non-verbal tasks for the three post-tests. Verbal Task IV was selected for comparison because children acquire this task prior to the other verbal tasks. Passing Task I only means that a child is categorized in stage 3 on Task I and in stage 1 on Task IV. On the other hand, passing Task IV only means that a child is in stage 3 on Task IV and in stage 1 on Task I. A similar interpretation is intended for passing Task II only. Selection of subjects that passed Task I only and Task IV only, as well as subjects who passed Task II only and Task IV only, insured independence of Tasks. Since the tasks were independent, the binomial test (Sigel 1956) was employed.

Table 6

Number of Subjects Passing Task I only and Task IV only

	Passing Task I only	Passing Task IV only	Significance of a difference
Post test I	59	28	p .001*
Post test II	74	42	p .001*
Post test III	87	40	p .001*

* Significant at .01 level

Table 7

Number of Subjects Passing Task I only and Task IV only

	Passing Task II only	Passing Task IV only	Significance of a difference
Post test I	44	30	n.s. *
Post test II	46	60	n.s. *
Post test III	58	58	n.s. *

* at the .05 level

The results of Table 6 and 7 indicate that while on the three post-tests, Task I is passed by significantly more subjects than Task IV, the non-verbal Task II does not have significantly more subjects passing it than Task IV. In fact only on Post test I do subjects make more stage 3 responses on Task II than Task IV. On the second Post test more stage 3 responses are made on Task IV than Task II. Therefore although it is safe to conclude that the non-verbal discrete task is passed by a greater proportion of the subjects than the verbal discrete task, no such conclusion is forthcoming when comparing the non-verbal continuous task with the verbal discrete task.

Discussion

Not only is it necessary to explain the failure of Smedslund's cognitive conflict training technique for conservation, but it is also necessary to explain why training in general for conservation appears unsuccessful.

To begin with an examination of the criteria ascertaining the effectiveness of training if conservation of substance is appropriate. In order for training in conservation to be effective according to Piaget (1964), two criteria, have to be satisfied, these are generalizability and durability. In other words the concept which was induced not only had to transfer to other situations, but the concept should not extinguish over time. Clearly, post-testing for violations of the concept of conservation over a period of 5 months satisfies the forementioned criteria. Whereas the criteria in these experiments satisfied Piaget's criteria this was not the case in any of the other training studies. In Beilin's training study, the generalizability criterion for testing whether the concept was induced was extremely limited and durability criteria was not satisfied at all. Similarly, in Smedslund's and Bruner's experiments the durability criterion was not met, whereas the generalizability criteria was limited. In Sigel's technique although the generalizability factor was met, the durability factor was not. Because these investigators employed different criteria, it is conceivable that the success in training that Beilin, Bruner, Sigel and Smedslund report relates not to the concept of conservation of substance as Piaget sees it, but rather to some other concept or some deformation of the concept of conservation. Adding credence to such a contention Almy et al (1966, p. 41) and Gruen (1966) stated that the selected training techniques depend on what ever theory about the nature of human learning the experimenter holds. Directly testing such an interpretation, Gruen (1966) demonstrated that the different criteria and the different procedures employed by Bruner and Smedslund led to a different classification of conserving responses. Although Smedslund's different criteria offer one explanation of results, a difference between the cognitive conflict position and Piagetian theory which Smedslund has recently reported may provide an alternative explanation for the lack of success of his training.

In an unpublished paper, Smedslund (1966) now suggests that the organism-object conflict which he espoused is not of sufficient moment to cause a modification of the intellectual structures. He suggests that the organism-object relation is too neutral for the child and does not or cannot create the conflict in the child. In other words, he suggests a confrontation of different points of view among children rather than a confrontation of different viewpoints between the child and object as a necessary condition for modification of intell-

ectual structures. Clearly, such a shift in position by Smedslund now makes his position identical to Piaget's rather than similar to Piaget as mentioned earlier. Further, Smedslund's argument (1966) for increased concentration on idiographic data rather than nomothetic data represents a potential shift in methodology from the standardized approach to one more in the direction of the clinical approach. Therefore, Smedslund himself now believes that both his cognitive conflict model and his approach need to be shifted in a direction more in line with the Piagetian position.

If Smedslund's argument is correct and if his position was most congruent with Piaget's then most certainly the other positions require a significant shift both in their training procedures and criteria to attain results similar to those of Piaget.

Some researchers, Sigel* in particular, argue that the lack of success of training may primarily be a function of the absence of intensive and extensive training. He argues that such training as described earlier may be too superficial to have any impact. Of course such a claim may be made to any training procedure which is found to be ineffective. Since there is no evidence to indicate that eight training sessions with ten minute sessions is inadequate nor is there any evidence to indicate that an increased number of training sessions with longer periods is adequate, the contentions of superficiality in training is without foundation. If the training as described above were successful then eight sessions in terms of its application to the school situation seems a practical possibility. But, since trained research assistants, most of whom are also experienced teachers, could not accomplish the task of inducing conservation with small groups of children, there is no reason to believe that regular teachers can accomplish this even in a longer period of time with a larger group of children.

On the other hand, suppose it were found that training children in groups of 2-3 for a period of 4 months for 6-7 hours a week was successful, clearly, the application of such a procedure to the school situation would be impractical.

The results have not only indicated that different training procedures are ineffective but further that these different training procedures are ineffective with a variety of populations. In particular, these results support the contention that children, regardless of their background, are at a particular stage of development and that specific training has little or no value as far as the concept of conservation is concerned.

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* Personal communication

Further these results do not support Reissman's contention that some training procedures, which rely more on the concrete and manipulation techniques, may be more successful with disadvantaged children than those which do not. In particular, Smedslund's training technique which relied more heavily on perception than the other training procedures, was not more effective with Project Head Start children than with other children. These results support the findings of Prager (1966) who trained her class of Project Head Start children with the Smedslund technique for a longer period of time. While adhering to the cognitive conflict technique, she was able to provide her children with many more manipulative experiences than the cognitive conflict technique described here. Yet, despite these additional experiences, the training was not successful.

An interesting but not surprising result were the significant effects of time in both analyses of variance. It was mentioned earlier that no interaction with pretest and time were evident, consequently these were not rival explanations for the significant increase. One is tempted to state that such differences are attributed in part to maturation and thus support the Piagetian position. Clearly, the problem of test wiseness and increased adult contact are also possible explanations. But Almy's findings (1966, p. 125) highlight the importance of maturational factors and general experience thus weakening the contention of test wiseness and increased adult contact as competing explanations.

Because of the apparent lack of effectiveness of various kinds of specific training, it becomes necessary to make explicit how specific training differs from cummulative life experiences which Piaget suggests are in part the determining factors for acquisition of the concept of conservation of substance.

Besides the obvious differences of time between cummulative life experiences and specific training, the ordering of experiences must be considered a relevant distinction. Clearly, the nature of <u>any</u> specific training involves a <u>deliberate</u>, ordering of experiences. In other words, the sequence of presentation is paramount. The assumption here is that the child will assimilate the relevant aspects (order, etc.) of these experiences and consequently acquire the concept. But this assumption is not tenable with a Piagetian framework. For if the child constructs his reality, then it does <u>not</u> necessarily follow that he will assimilate the material in the <u>order</u> presented to him. Accordingly, it is conceivable that the child will assimilate the material in a different order and will utilize the language differently from the way it is presented, (namely inappropriately). In addition, the child may only

assimilate part of the material. To illustrate, for the infant, a pillow is not cognized as an object to sleep on but rather an object to be sucked. Smedslund (1966) supports such an analogy when he suggests that the only thing training may do is to support notion that the equality of sets of chips is established. Here children can cognize the specific rows as equal but not that the number is the same. By contrast the cummulative life experiences do not order the events for the child, because the child assimilates those events which fit into his construction of reality. If for example, however, a child is in the transitional stage of conservation of substance, it may be that his assimilation of events then corresponds or at least more clearly approaches the ordered presentation of the training.

Methodological Considerations:

(a) Verbal-Non-verbal:

Although the non-verbal discrete task was passed by a higher proportion of subjects than the verbal discrete, the non-verbal continuous task was not passed by a higher proportion of subjects than the verbal discrete. The latter finding is disturbing since in an earlier study Mermelstein and Shulman (1967) with 6 and 9 year olds found that a significantly high proportion of subjects passed the non-verbal continuous as opposed to the verbal discrete.

Since the apparent difference between both discrete tasks (verbal and non-verbal) is just the verbal component, there is some evidence to the claim that concepts are acquired without the use of language. In addition, there also appears to be some evidence that language may be an inhibiting factor rather than a facilitating factor. Perhaps two examples will highlight the possible interference of language in concept acquisition. Many children when confronted with the non-verbal tasks, in particular, the non-verbal discrete task claimed that there were the same marbles in both containers even though one container had ten marbles while the other container had 20 marbles. In particular, a child in the first post-test (in the pilot study) on the non-verbal discrete item claimed emphatically that the marbles in both containers were the same, even though one container had 20 marbles while the other container had 10 marbles (a non-conserving response). On the second post-test this child returned to the "perceptually" more appropriate response of claiming that the marbles in both containers were not the same number, (a non-conserving response). In a second example, there were numerous instances when children confronted with two rows of eight chips each first acknowledged their equality but when they began to count the

numbers of chips they lost sight of their equality and they then maintained that the rows of chips were not equal. Consequently, it appears that the language aspect of the training may not only be inappropriately applied (example 1) but that also the mere act of verbalizing may interfere with concept acquisition (example 2). In support of example 1, Almy et al (1966, p. 82) states that:

> "most of the children (middle class and lower class) do not appear to have any coherent system for handling the problem of sameness when it relates to number. In the middle class group most of them have the requisite vocabulary but many do not yet apply it in ways the adult would regard as appropriate".

Contrary to Bruner and Beilin in particular, Almy further states that attempts to improve the child's logic solely through instructing him in the use of language are not likely to be successful. Accordingly, such evidence is contrary to the position that language facilitates concept acquisition.

(b) Reversals:

The problem of subjects shifting from stage 3 responses on post-test I to a stage 1 response on post-test II or post-test III are described as reversals. Because approximately 20% of the subjects manifested such reversals from post-test I to post-test II and post-test II to post-test III, the subject merits some discussion. In an earlier study Mermelstein et al (1967), it was noted that several explanations may account for these shifts. Because of the random assignment of experimenters to each post-testing, it is unlikely that experimenter bias, (not controlled for in the earlier study) played a role in these reversals. Although the inherent unreliability of the items of the post-test may be a factor, the transitory nature of the concept of conservation seems a more compelling explanation for the reversals. Almy (1966, p. 108) also reports the shifting from stage 3 responses to stage 1 responses. She reports that about half the children at least at one point in the series of interviews, "regressed" from what appeared to be an understanding of conservation at an earlier period. Since these conservation tasks have had confirmation with other subjects, it seems unlikely that a difference would be solely attributable to the reliability of items. Piaget (1966) indicates that the problem of reversals or regression is related to differences between the clinical and standardized approach. He notes that his colleagues employing the clinical method found no instances of regression. Clearly, the problem of reversals merits further exploration.

Implications for Education:

The results of various training procedures cast doubt on the efficacy of short-term training in number development at both the pre-school and kindergarten level. And further these results do not support the contention that some training procedures which rely heavily on manipulative and concrete materials are more efficacious with Head Start children than those training procedures which do not.

These results do not undermine the value of pre-school and kindergarten experiences but rather question the virtue of specific training experiences. Clearly, increased contact with adults and other children provide valuable experiences in role playing and confrontation of different viewpoints. Acording to Piaget, the child's role playing and confrontation of different viewpoints serve as key factors in intellectual development. It may be that training procedures which involve role playing procedure would produce more significant results. Fiegenbaum (1967) is presently examining the effects of role playing on the acquisition of conservation.

Conclusions:

It is concluded that the "Piagetian" concept of conservation of substance, as measured by the specific criteria described, was **not** induced by a variety of training techniques with various populations. Further, it is suggested that language interferes with rather than facilitates acquisition of the concept of conservation of substance. Finally, it is concluded that the problems of reversals merits further exploration.

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Appendix A

Dunnett's test requires that all scores be independent of each other. Thus, the average score for each subject across all three post-tests was computed and used in this analysis. We are interested only in the case where a true treatment mean is greater than the true control mean and use the table of "t" for One-Sided Comparisons for a Joint Confidence Coefficient of P = 95%. (Dunnett p. 1117 or Edwards p. 378). Dunnett has computed tables for P = 95% and P = 99% only.

From the above mentioned table a value having the probability of .95 that none of the treatments will be declared superior when, in fact, all are equivalent, was obtained. In our case, with 4 treatment groups, the tabled value of "t" was 2.16. In order for a difference between a treatment mean and the control mean to be significant, it must be equal to or greater than this value times the mean square within groups.

$$\frac{(\bar{X}_k - \bar{X}_a) - (M_k - M_a) \geq t}{\sqrt{\frac{2S^2}{n}}}$$

S^2 = mean square within groups

Since null specifies that $m_k - m_o = 0$

$$\bar{X}_k - \bar{X}_a \geq t \sqrt{\frac{2S^2}{n}}$$

In our case: $t = 2.16$

$$\sqrt{\frac{2S^2}{n}} = \sqrt{\frac{2(.2601)}{60}} = .0931$$

$$\bar{X}_k - \bar{X}_a \geq 2.16\ (.0931)$$

$$\bar{X}_k - \bar{X}_a \geq .2011$$