1976

The Effects of Interaction with Conserving Adults and Peers on the Acquisition of Conservation by Nonconservers

Douglas Arthur Smith
Wilfrid Laurier University

THE EFFECTS OF INTERACTION WITH CONSERVING ADULTS AND PEERS

ON THE ACQUISITION OF CONSERVATION

BY NONCONSERVERS

by

DOUGLAS ARTHUR SMITH

A thesis submitted to the Department of Psychology

in conformity with the requirements for

the degree of Master of Arts

Wilfrid Laurier University

Waterloo, Ontario, Canada

October, 1976

The Effects of Interaction with Conserving Adults and Peers
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Nonconserving children were placed in a situation where they had to interact with either two conserving adults or two conserving children. Each triad (one nonconserver and two conservers) was asked to give judgments and explanations for conservation problems. The type of conserving explanations (invariant quantity, reversibility, and compensation) given by the conservers in the interaction were varied. Approximately one week after the interaction the nonconserving subjects were posttested and the results indicated that nonconservers increased in conservation score after interacting with conservers. Hearing different explanations did not differentially affect the scores of nonconservers. The results did indicate that invariant quantity explanations were used more often than either reversibility or compensation explanations by the subjects after the interaction. There were no differential effects when interacting with either adult or peer conservers. These results were discussed in terms of Piagetian Theory. The ramifications of these findings on our educational system were discussed as were suggestions for future research.

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According to Piaget (1950, 1957, 1969), adult intelligence (adaptive thinking and action) is derived from the earliest sensorimotor coordination of infants, in a series of stages related to age. These stages are the Sensorimotor Period, the Pre-operational Period, the Period of Concrete Operations, and the Period of Formal Operations. Piagetian Theory is a "nature" theory in the sense that the sequence of stages is determined by maturational factors, but it is also a "nurture" theory in the sense that the age at which any particular stage is achieved depends upon individual differences in ability, background, and experience.

The Sensorimotor period occurs between birth and two years of age. During the early months of life the young infant behaves as if the world about him were a kind of motion picture, a continuously changing panorama of events, no one of which has any permanence. Toward the end of the first year, however, the infant begins to seek after objects that have disappeared. This gives evidence that he now attaches permanence to objects that are no longer present to his senses. For instance a child at the age of one will watch a toy train go into a tunnel and look at the other end for it to come out. During this period the infant acquires an elementary notion of causality and begins to anticipate the results of his actions. Toward the end of the second year his spatial concepts are also well elaborated and he usually knows the floor plan of his home quite well and can get where he wants to go with ease.

The Pre-operational period which occurs between two and six years of age is marked by the emergence of what Piaget refers to as the symbolic function, or true systems of representation, such as language. The infant in this period can use both signals (stimuli which through conditioning come to elicit particular behaviours, like the sight of a bottle which signals sucking) and signs (such as a parent putting on a coat which is the sign that the parent is going outside).

Although children in the Pre-operational stage make remarkable progress in symbolic activities, particularly language expression, their ability to deal with classes, relations, and numbers is quite limited. For example, Pre-operational children have difficulty in distinguishing between "some and all" and between the use of a class term to represent a single member of the class and the use of it to represent the class as a whole. If a child at this level is confronted with 20 blocks of wood, 15 of which are red and the other 5 being blue the child would probably say there are more red blocks than blocks of wood. In the realm of number, the Pre-operational child can usually discriminate up to three or four and may be able to count to twenty, but he cannot coordinate his verbal counting with the enumeration of elements.

The Period of Concrete Operations occurs around the ages of six or seven to eleven or twelve. "The operations involved in this period are called "concrete" because they relate to objects and not verbally stated hypotheses" (Piaget, 1969, p. 100). The child in concrete operations can deal with combinations of classes. Also during this period children are able to arrive at a true concept of number and to perform the elementary operations of arithmetic. It is during this period that the child acquires the concepts of conservation of quantity, length, weight, number,volume, and area. Piaget refers to conservation as the ability to realise that changes in some dimensions i.e., shape, thickness, do not necessarily constitute changes in other dimensions i.e., quantity, weight.

The child during the Period of Concrete Operations is limited for the most part, to dealing with at most two classes or relations at a time. The adolescent during the Period of Formal Operations (eleven to twelve years of age to fifteen years of age) is not limited in this respect and is able to engage in the kind of thinking that is characteristic of scientific experimentation. The notion of proportions as well as certain forms of probability develop in this period.

Piaget categorizes the development of human beings from birth to fifteen years of age into four periods. In the present thesis we are interested in the transition from the Pre-operational level to the Period of Concrete Operations, dealing specifically with the acquisition of conservation.

Conservation problems deal with the assessment of the child's realization that a quantity remains unchanged regardless of changes in its appearance. Conservation is considered by Piaget (1952, p.3) as "a necessary condition for all rational activity". Piaget (1969) states that the operations in conservation consist of reversible transformations. This reversibility takes two forms: inversions, where +A is reversed by -A, and reciprocity (compensation) where $A < B$ is reciprocated by $B > A$.

Piaget suggests that once a child attains conservation, he is not aware of his own part in the process and treats his judgment as if it were rooted in the materials themselves. In the area of conservation the majority of Piaget's research deals with the conservation of number, mass, weight, volume and area.

Although Piaget is quite explicit on how to identify a nonconserver and a conserver he does not devote much discussion to the actual transition from nonconservation to conservation. He does, however, describe some of the concepts which are involved in the transition. These concepts are conflict and disequilibrium which are described in Piaget's (1967) equilibration theory. Piaget refers to equilibration as a process of balance between assimilation and accommodation in a biological sense. An individual perceives his environment by assimilating all new information. If something presents itself in such a way that he cannot assimilate it, he must change his view and accommodate if he wants to incorporate this new system.

According to Kuhn (1974) the child is an active operator whose actions are the prime generator of his own psychological development. When he is in a relatively equilibrated state, he will not tend to change. He will only change if he feels, consciously or unconsciously, that something is wrong (i.e., in a state of disequilibrium). According to this theory disequilibrium is the direct result of the input of discordant information into the existing structure. Disequilibrium may then lead to reorganization and progressive change.

Thus it can be seen that the process of equilibration involves the interaction of conflict, disequilibrium, and equilibrium. Conflict arises with the input of discordant information which leads to a state of disequilibrium. The child then employs accommodation or assimilation to overcome this state and reestablish equilibrium. In this way the child changes his mental actions and develops (Piaget, 1967).

Smedslund (1961b) proposes that "a state of cognitive conflict is the precursor of the cognitive reorganization that is required to support conservation" (p. 153). This proposal is consonant with the Piagetian notion that problems provoke cognitive disequilibrium. The resolution of this disequilibrium requires a new integration of distinct operations, such as simultaneously, instead of separately, attending to height and width in substance conservation or to both end points in length conservation.

Piaget stresses equilibration theory in his writings on cognitive development. There are, however, different methods of inducing cognitive development and one of these methods is through what the child experiences as discordant perceptual information.

According to Piaget (1950, 1960), between the period of infancy and adulthood, there occurs a number of inter-related processes that enable perception to become progressively more objective and reliable, and overcome the distortions to which perception is inherently subject. Piaget maintains these distortions are due to two characteristics of our perceptual equipment. The first is that the stimulus field is not perceived as being homogeneous, that is, part of it is perceived more clearly and vividly than the rest. Secondly, the direction of centering changes from moment to moment in a more or less random fashion, so that we perceive various elements of the stimulus field dilate and shrink in turn as we attend to one after another. Larger elements will attract more centerings than smaller elements so that they will undergo a net overestimation amounting to an illusion, in the subject's overall impression of a figure. Nevertheless, changes in centering will alter the appearance of the figure from moment to moment and thus introduce incompatibilities between the properties that it seems to have at different times. When the child becomes capable of retaining an impression long enough to compare it with the one yielded by the next centering, there will arise a state of "disequilibrium" or conflict.

Smedslund (1961b) studied the effects of cognitive conflict on acquisition of conservation in a situation without external reinforcement. Smedslund suggested that the acquisition of conservation in this situation would be a strong argument in favour of Piaget's "equilibration theory". As stated earlier, equilibration theory is the position of Piaget (1967), suggesting that "logical structure is not originally present in the child's thinking" (p. 7). It develops as a function of an internal process (equilibration) which is heavily dependent on activity and experiences. Thirteen subjects were given pretests on conservation of substance and weight and on transitivity of weight. In the training sessions the experimenter always started out with equal objects (i.e., balls of clay) and then would add or subtract small parts to or from one of them. Smedslund (1961b) suggested that the child would have to reach a decision as to the relative size of the two changes, and the state of inner conflict and uncertainty preceding this decision would have the effect of inducing pronounced cognitive changes and speed up the acquisition of conservation. After the training sessions the child was tested on conservation questions to see if they had followed the addition-subtraction schema. The results indicated that five of the thirteen subjects conserved to some degree on the posttest while the other eight subjects gave only nonconservation answers. Smedslund suggested that because five of the subjects acquired conservation through this procedure then this gave support for the equilibration theory, a rather strong conclusion considering the fact that only five subjects acquired conservation and even these five subjects were not all able to conserve on every question.

Murray (1968) found that the combination of cognitive conflict and reversibility training did produce the acquisition of length conservation. To induce cognitive conflict Murray had each subject perform actions that made the same stick appear sometimes longer and sometimes shorter than an equal length stick. This was accomplished by the use of the Muller-Lyer illusion in the training trials where the child would manipulate two equal length sticks so that one would be in the longer illusion first and the shorter illusion the next time. Murray hypothesized that to conserve any property the child presumably needs a rule that allows him to get from the original state to the transformed state and back (i.e., reversibility). He devised the reversibility procedure used in this study to produce a conflict between the original and the transformed states. To resolve this conflict the subject was allowed to perform the actions that connected the two states.

In the pretest the experimenter placed two equal length sticks in the Muller-Lyer configuration. The child was asked if they looked the same and then the child was asked if they would look the same if they were placed side by side. The training session for the experimental subjects consisted of having them pick up the sticks in the Muller-Lyer configuration and replace them. Also the experimenter instructed the subjects to try switching the sticks. This particular procedure was intended to induce conflict in the subjects by having them perform the reversible operation of switching the sticks from one part of the Muller-Lyer configuration to the other. A group of control subjects were pretested and then went on to the posttest. There were three configurations used in the posttest; the Muller-Lyer configuration, the Oppel Inverted T Illusion, and the Jastrow Illusion (area).

In the posttest each subject was scored as having conserved length only if judgments of length of the sticks were unaffected by the Muller-Lyer Illusion. Murray found that the trained subjects were able to conserve on the Muller-Lyer and the Oppel Inverted T Illusions significantly more than the control group. There were no differences found between the trained and control subjects on the Jastrow area conservation task. Even though this procedure did produce the acquisition of length conservation it is not possible to give a conclusive answer to the question of whether or not the "cognitive conflict" had any effect on the acquisition of conservation because training was also involved.

The examples given above discuss how cognitive conflict can be induced through perception. One other method of inducing cognitive conflict is communication conflicts during social interaction. In 1926, Piaget suggested that a necessary condition for the movement from the stage of pre-operational or egocentric thought to more mature stages of thought was the occurrence of repeated communication conflicts between children. Although peer interaction is classified by Piaget as being one of the main vehicles of cognitive growth there have been few studies which have focused on this subject.

Silverman and Stone (1972), Silverman and Geiringer (1973) have investigated the question of whether experience in a problem-solving group (dyad) affects relatively permanent and generalizable changes in the cognitive functioning of the participants. In the Silverman and Stone (1972) study, children who conserved area and those who did not were given the task of reconciling their differing views. The subjects were required to reach consensus on each of the problems. This procedure was found to be effective in that the children who were not able to conserve area problems in the pretest were able to on the posttest.

Silverman and Geiringer (1973) studied the same process with specific interest in predictions from Piaget's equilibration theory. Piaget (1967) postulates that the inherent tendency of mental structures "consists not only in re-establishing equilibrium but also in moving toward a more stable equilibrium than that which preceded the disturbance" (p. 7). Piaget further theorizes that the degree of stability of mental structuring increases with each successive stage of development. From this Silverman and Geiringer predicted that, "all things being equal, attempts to change the child's mode of thought should be more successful when he is exposed to concepts that reflect a higher rather than a lower stage of development" (p. 816).

The results of the Silverman and Geiringer (1973) experiment supported the equilibration model on several counts. Silverman and

Geiringer found that nonconservers yielded to conservers more frequently than conservers yielded to nonconservers. This finding reinforced the Piagetian notion that more advanced stages of intellectual development are also more stable. Secondly it was found that nonconservers who yielded to conservers retained and generalized the conservation concept. Thus Silverman and Geiringer hypothesized that because nonconserving children were presented with the views of a higher intellectual level, conflict and disequilibrium were aroused and the resulting resolution of the disequilibrium was enough to advance the child into a higher stage of intellectual functioning. Finally, conservers who yielded reverted back to the conservation point of view. Thus yielding to nonconservers may have been due mainly to social pressure and not an actual reorganaization of thinking.

Murray (1972) also studied the effect on conservation of a nonconserving child being confronted with opposing points of view. He expected that a young child's ability to give conservation judgments, and to support those judgments with adequate reasons, would improve after the child had been subjected to contrary arguments and viewpoints of other children. Murray administered Form A of the Concept Assessment Kit-Conservation (see Appendix A) to 108 kindergarten and first grade students. Each subject who scored between 0 and 4 (nonconserver) was grouped together with two conservers (those who had scored between 10 and 12 on the Concept Assessment Kit). All triads were given Form A again and told that they would not receive a score until all three members of the group agreed on the answer and the explanation. The children were instructed to discuss any disagreements about the correct answer. One week later each subject was tested alone on Forms A, B and C of the Concept Assessment Kit. In all triads there were significant increases in conservation scores between pretest Form A and the posttest Forms A, B, and C. Those subjects who had demonstrated on the pretest that they were conservers, also showed an increase in conservation scores. Murray concluded that "social conflict or interaction between children is an important mediator of cognitive growth" (p. 4).

Brison (1966) designed an experiment to study the acceleration of conservation by training on decentering or in Piagetian terms "compensation". Subjects were assigned to either experimental or control groups after a pretest on conservation of substance and continuous quantity (sand). The control group went from the pretest to the posttest without any treatment. The experimental nonconservers were assigned to six subgroups (all subgroups went through the same treatments). Two conservers were randomly assigned to each of the subgroups. The subjects in each subgroup were shown two identical cylindrical glasses A and B with glass A having more juice than glass B. The liquid in glass A was then poured into a short fat glass (C), and the liquid in glass B was poured into a tall thin glass (D). The children then pointed to the glass which they wanted to drink. The liquid was then poured into glass A and B and subjects were given the amount they chose. A child who chose the glass with the most liquid (conserver) was asked to give an explanation of why he or she chose the particular glass. The procedure was repeated two more times, using different pairs of unequal glasses. It was expected that the subjects would acquire conservation because of less reinforcement of nonconservation choices and also because of the effects of hearing conservers explain their conservation responses.

Brison's experimental groups did in fact acquire conservation of substance. It is not clear, however, whether it was differential reinforcement or the interaction of nonconservers and conservers, or a combination of both which produced the acquisition of conservation by nonconservers.

Rothenberg and Orost (1969) did a series of experiments in which nonconserving kindergarten children were given individual instruction in conservation by two female experimenters. In addition, in two of the three experiments in this series, as well as the female experimenters, "assistant teachers" who were slightly older conserving peers, gave individual instruction. During four 15 - 20 minute individual training sessions, the subject was presented with a sequence of concepts derived from an analysis of the components assumed to underlie the acquisition of the concept of conservation of number. The major concepts were rote counting, counting attached to objects, "same" number, the "same" versus "more" distinction in terms of number, addition and subtraction representing a change in number, one-to-one correspondence, reversibility and the distinction of "more" referring to the actual number of objects versus "longer" referring to their arrangement in space.

The purpose of the "assistant teachers" was to create a peer-peer conflict. That is, a confrontation of different points of view among children. All of the possible "assistant teachers" (those who were conservers on the pretest) were evaluated prior to the actual training sessions with "practice" nonconservers, and those who showed the greatest ability to communicate effectively were chosen as teachers.

Conservation was induced, but again the reason for conservation is not clear. It may have been the peer instruction or adult instruction or an interaction of both. Rothenberg and Orost (1969) suggest that among the most revealing of the techniques used was that of peer instruction. Observation of the interaction among the experimenter, the "assistant teacher", and the subject indicated that the assistant teacher often seemed to be able to communicate in more meaningful terms to the subject than could the adult. Rothenberg and Orost (1969) also suggested that the small age difference between the two children probably made it feasible for the younger subject to reasonably strive for something (i.e., conservation of number) attained by the older child in contrast to being presented only with adult expectations as the standard for achievement.

The literature, as can be seen above, does not give any indication whether nonconserving children become conservers (or at least increase in conservation score) more when interacting with conserving peers or conserving adults.

As stated earlier Piaget (1926) has suggested that peer-peer interaction is a necessary condition for the movement from the stage of preoperational thought to more mature stages of thought. Piaget has also stated (1926,1932) that children are less egocentric with other children than with adults. Piaget defines egocentricity as the centering of one's viewpoint to the exclusion of other viewpoints. Hence, the child might be more likely to revise his position when the discrepant information comes from a child rather than an adult. Therefore Piagetian Theory would perhaps predict that a peer would affect the performance of a nonconserving child toward conservation more than would an adult. The present study is designed in part to determine whether nonconservers will increase in conservation score after interacting with conservers and whether there are any differential effects on the conservation score of nonconservers after interacting on conservation questions with conserving adults and conserving peers.

Another facet of the concept of conservation is the types of explanations used by conservers when answering conservation explanations. Piaget has identified three types of adequate conservation explanations. These are reversibility, compensation, and invariant quantity (identity). A reversibility explanation is one which notes the fact that the transformed object can be changed back into its original form. A compensation explanation refers to changes in two dimensions. For instance when referring to a piece of plastercine which had just been changed from the shape of a ball to that of a hot dog a conserving child may say that the piece of plastercine is longer but thinner. A child using an invariant quantity (identity) explanation would state that nothing had been added or subtracted or that only the shape had been changed.

Piaget (1964, 1971) when discussing the three types of explanations refers for the most part to reversibility and compensation. However, he does make it clear that all three explanations are independent of each other and that they do not correspond to three sub-stages. Piaget does indicate that invariant quantity ranks as an argument of conservation only when the other two arguments have been discovered. Although this may seem to be contradictory, (independent versus reversibility and compensation first) Piaget (1950) has clarified the situation by stating that nonconserving children do in fact have knowledge of invariant quantity, reversibility, and compensation but they are still not able to conserve. In other words, before children acquire conservation they have some understanding of the concepts of invariant quantity, reversibility, and compensation. Therefore Piaget treats each of these forms of conservation explanation as equally acceptable.

There have been studies which examined whether one of the explanations is developmentally prior to the other. Brainerd (1972) looked at whether simple contingent reinforcement induces conservation in previously nonconserving subjects and also whether either or both of Piaget's cognitive reversibilities (reversibility or compensation) were associated with conservation acquisition. Brainerd (1972) did not refer at all to the invariant quantity type of explanation and may have classified invariant quantity explanations as either reversibility or compensation.

In Brainerd's study there was a group of 12 natural conservers (those who scored as conservers on the pretest), 20 experimental nonconservers and 20 control nonconservers. The experimental group was "reinforced" (i.e., telling the subject that he or she was wrong) while the control group was not reinforced. Other than that they went through the same procedure. Neither the experimental nor the control subjects were required to explain their training phase judgments. Brainerd reasoned that if either or both of the two reversibilities was a necessary precondition for conservation, then one would expect that the reinforced subjects should tend to shift their explanations to include some mention of reversibility.

Brainerd found that the "reinforced" group did acquire conservation and that this group and the natural conserver group did not differ in their number of inadequate explanations. The experimental subjects did give significantly more reversibility explanations and significantly fewer compensation explanations than did the natural conservers. Brainerd suggests that these results indicate that the reversibility type of explanation may be developmentally prior to the compensation type of explanation.

Piaget treats invariant quantity, reversibility, and compensation as equally acceptable as conservation explanations and therefore establishes no specific order of developmental sequence for them. Brainerd's (1972) results suggest that reversibility may well be developmentally prior to compensation.

A further purpose of the present experiment is to study the effects on conservation scores of nonconservers after hearing the different types of conservation explanations from conservers. Also in the present experiment if the nonconserving children do increase in conservation score then it will be of interest to see whether these subjects give one type of explanation more often than the others on the posttest. In this particular case however, we shall be looking at all three types of explanations.

In summary, the present experiment attempts to determine whether nonconservers hearing conservation judgments and explanations from other children increase in conservation scores to a greater extent than nonconservers hearing conservation judgments and explanations from adults, and whether there is any effect on increase in conservation scores when nonconservers hear the different types of explanations.

METHOD

Subjects

Seventy nonconserving children (37 female and 33 male) in kindergarten and grade one were chosen from the Waterloo County Separate School System. The subjects ranged in age from 4 years 8 months to 7 years 1 month with the mean age of 5 years 10 months. University students and children from grade two were employed as confederates.

Design

The present experiment is a 2 X 3 X 3 repeated measures design with peer versus adult as one independent variable and the type of explanation (invariant quantity, reversibility, and compensation) as the other independent variable and the pretest, posttest B and C as the repeated measure. In order to investigate any effects outside the experimental treatment a control group was studied.

Materials and Procedure

The Concept Assessment Kit - Conservation (Goldschmid and Bentler, 1968) was used. This kit has three forms of conservation problems. Form A and Form B are parallel forms and may be used as pretest - posttest forms (Goldschmid and Bentler, 1968). Form C consists of conservation problems which are not directly similar to Forms A or B.

Each experimental subject underwent three sessions (pretest, interaction, and posttest). The pretest and posttests were given individually. The interaction session involved groups of three (two conserving children or adults and one nonconserving subject). The control subjects were only given the pretest and posttest sessions.

The time interval between both the pretest and the interaction as well as the interaction and the posttests was approximately one week. The control subjects were posttested approximately two weeks after the pretest.

Two different rooms were used in the present study as it was conducted in two different schools. Both rooms, although different sizes (one was a staff lunch room and the other was an empty classroom), had large enough tables to seat three people on one side. The experimenter sat across the table from the subjects and the conservation material was placed in front of the subjects when being manipulated and placed at the far end of the experimenter's side of the table when not in use.

After obtaining permission from the children and their parents subjects from grade one and kindergarten were individually pretested on Form A of the Concept Assessment Kit. Form A provides a standardized individual testing procedure for six conservation problems (two-dimensional space, substance, weight, number, continuous and discontinuous quantity). In scoring the responses the child was given one point for each correct judgment and one point for an explanation that noted either invariant quantity, reversibility, or compensation. Thus a maximum score on the form was 12 points. Of the 101 subjects pretested those who scored as non-conservers (70 subjects) were chosen and randomly placed into six experimental groups and the one control group. To be classified as a nonconserver a child had to have scored 5 or less on Form A.

The conserving children were chosen from grade two. A pilot study indicated that a majority of nonconservers came from grades one and kindergarten. By selecting conserving children from grade two it was possible to ensure that these confederates were not known by the non-conserving children. This was made possible by telling the conservers before the interaction the names of the subjects and asking the conservers whether they knew the child well, not well, or not at all. Not knowing the child well was defined as having heard the child's name but never interacting with the child.

Children from grade two were pretested on Form B of the Concept Assessment Kit and were classified as conservers if they obtained a minimum score of ten out of the possible score of twelve. Ten children (5 from each school) who scored as conservers were asked if they would help the experimenter in a project he was doing in their school. The children were told that their involvement in the project would mean about 1½ to 2 hours of class time. Approval for their participation in the experiment was also obtained from the principal, teacher, and the parents. After permission was acquired the children were given training sessions on all the three types of explanations.

The training sessions were used to teach conservers the logic of the types of explanations to be used and not to give them the exact words to use. Manipulations of material other than those used in Form A were shown. This was also so that the child could grasp the concept. For example, when training invariant quantity, pennies were used as one manipulation. The pennies were changed into many different shapes and forms and the child observed that the number did not change. What was impressed upon the child was that the shape of a stimuli can change without there being any more or less of it. Other material such as sticks were also used. After this initial instruction Form A was given to ascertain whether the child could use the type of explanation trained. If at any time the child did not use the proper concept the experimenter reminded him of the instructions. "Do you remember what we were talking about before with the pennies and things, does that make you think of another explanation". In this way it was hoped that the child would be able to formulate in his own mind the concepts of invariant quantity, reversibility, and compensation. It was found in all cases that the confederates could use the explanation after this instruction. For the training of reversibility and compensation refer to Appendix B.

After the training the child was told of the upcoming interactions and that he was to answer the questions in the interaction in one of the ways which he had just answered them. It was also emphasized that during the interaction the conserving child was to explain his or her own answers to the best of his or her ability. If the child had any questions they were answered at this time.

Before each interaction two randomly selected conserving children were brought into the experimental room. The conservers were told which type of explanation to use (designated type A, type B or type C) and were asked conservation questions to make sure that the children remembered what was expected of them. If one or both of them did not seem to remember then some of the training manipulations were gone over as well as some of the questions on Form A. This second training session was ended when the experimenter was sure that the concept had been mastered. It was found again that any difficulty was corrected in a few trials.

A similar training method was employed for all of the types of explanations. This method controlled for the types of explanations which were used and also allowed some freedom of expression for the conservers. It was felt necessary that the children and adults express themselves in their own words because what was being investigated was the effects of hearing adult's and children's conserving judgments and explanations on the performance of nonconservers.

Four adult confederates were instructed in a similar way (excluding the pretest). The different explanations were explained by using the same manipulations that were used with the conserving children. It was also stressed that they were to use their own words and to explain to the best of their ability. The same examples that were used in the training of the child conservers were also used with the training of the adult conservers.

In the interaction session one nonconserver and two conservers (adults or children) were asked the questions from Form A again. The experimenter first asked the nonconserver for his or her judgment. Then the first conserver was asked for his or her judgment. If there was a disagreement (if the nonconserver gave a nonconserving judgment) then the first conserver was asked to give an explanation. The second conserver was then asked to give a judgment and an explanation. Finally the nonconserver was asked again for his or her judgment and also for an explanation. This procedure was followed for all six conservation questions. If at some time the nonconserver gave a conserving judgment then the two conservers were asked for their judgments only. The experimenter then asked the three for their explanations in the same order as their judgments were asked for. All questions on Form A were asked during the interaction. It was found that in only three cases did the peer conservers make a mistake and give the wrong explanation. As soon as this happened the interaction was terminated and after the nonconserver left the conservers were told of their mistake. The data from the nonconservers involved was discarded.

Approximately one week after the interaction the posttest was given. Each nonconserving subject was tested individually as in the first session (pretest). Conservation problems from Form B and C of the Concept Assessment Kit were presented. As on Form A, each problem on Forms B and C was scored one point for a correct judgment and one point for an appropriate explanation.

RESULTS

The mean scores and standard deviations of the conservation scores on the pretest and both posttests for all experimental treatments and the control group may be found in Table 1 and Figure 1. All analyses of the data may be found in the appendix section.

The purpose of the present study was to determine whether there were differing effects on the conservation scores of nonconservers after hearing either adult or peer conservers give conservation judgments and either invariant quantity, reversibility or compensation explantions. In order to determine this a three factor analysis of variance with repeated measures on the forms of the Concept Assessment Kit-Conservation was calculated. The repeated measures were the pretest, posttest Form B and posttest Form C.

The results of this analysis suggest that there was a significant effect over the repeated measures (Forms of Kit) ($F = 108.3$, $df = 2, 108$, $p < .01$). The summary table for this analysis of variance can be seen in Appendix C. Newman-Keuls analysis of the main effect on forms of the kit suggests that nonconserving children hearing conservation judgments from both adults and peers give significantly more conservation judgments and explanations on Form B and C than on Pretest Form A ($p < .05$). Also the Newman-Keuls analysis suggests that nonconserving children hearing conservation judgments from both adults and peers give significantly more conservation judgments and explanations on

TABLE 1

The mean conservation scores and standard deviations of each treatment group over the three forms of the Concept Assessment Kit - Conservation are given in Table 1. The conservation scores may range from 0 - 12. The nonconserver is given one point for each conservation judgment and one point for each correct explanation.

Table 1

Mean Scores and Standard Deviations of Treatment Groups and Control Group on Pretest and Posttests Concept Assessment Kit-Conservation

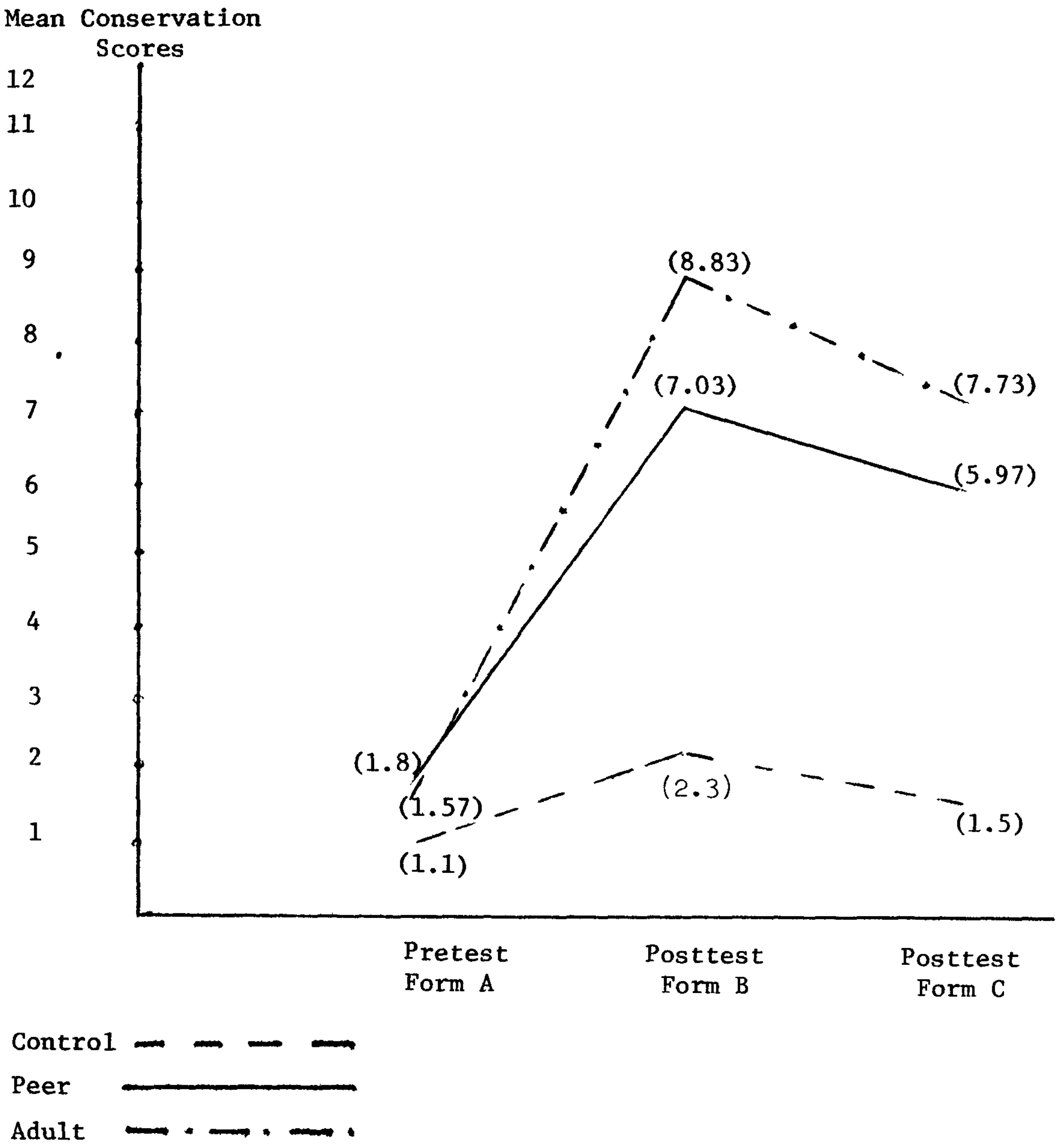
Treatment	Pretest Form A Mean	S.D.	Posttest Form B Mean	S.D.	Posttest Form C Mean	S.D.
Peer						
Invariant Quantity	1.3	(1.95)	6.7	(5.64)	5.8	(2.97)
Reversibility	2.5	(1.96)	9.1	(3.14)	7.4	(3.66)
Compensation	1.6	(2.01)	5.3	(3.62)	4.7	(3.33)
Mean	1.8		7.03		5.97	
Adult						
Invariant Quantity	2.3	(2.06)	10.5	(1.77)	8.4	(2.22)
Reversibility	1.0	(1.25)	8.9	(4.43)	6.7	(4.33)
Compensation	1.4	(1.65)	7.1	(3.35)	7.0	(1.94)
Mean	1.57		8.83		7.37	
Control	1.1	(1.45)	2.3	(1.62)	1.5	(1.72)

FIGURE 1

The mean conservation scores of the peer, adult, and control groups over the three forms of the Concept Assessment Kit - Conservation are compared diagramatically in Figure 1. The peer and adult treatment group increase in conservation score significantly from the pretest to both posttests. Also in both the peer and adult treatment groups there is a significant decrease in conservation score from posttest Form B to posttest Form C. There is no significant difference in conservation scores from the pretest to either posttest or between posttests in the control group.

Figure 1

Mean Scores on Concept Assessment Kit-Conservation of Treatment and Control Groups on Pretest and Posttest



Form B than on Form C ($p < .05$). The summary tables for the a posteriori comparison may be found in Appendix D.

There was found to be no difference in increase of conservation score when nonconserving children hear conservation judgments and explanations from adults or peers ($F = 2.77$, $df = 1, 54$, $p > .05$). Also there was found to be no significant differences in increase of conservation socre when nonconserving children hear either invariant quantity, reversibility, or compensation explanations from conserving adults or peers ($F = 2.44$, $df = 2, 54$, $p > .05$). In addition none of the interactions were found to be significant ($p > .05$).

As was stated earlier a control group was studied to look at any effects which may have been due other than to the experimental manipulation. There was found to be no significant differences when comparing the pretest scores of the experimental nonconservers and the control nonconservers ($p > .05$). A comparison of the means of the experimental nonconserver scores and the control nonconserver scores on both posttests was found to be significant using the t test for independent samples (Posttest Form B, $t = 5.27$, $df = 68$, $p < .05$; Posttest Form C, $t = 4.91$, $df = 68$, $p < .05$).

Comparison of control and individual treatment means for the pretest and both posttests was done. Analysis using the Dunnett's test for comparing all means with the conrol suggests that for the pretest there were no significant differences ($p > .05$). When comparing the control means with the treatment means for both posttests it was found that all comparisons were significant at the .05 level of confidence except one. The comparison of the scores on Form C of the control nonconservers and the treatment nonconservers who heard compensation explanations by peers indicated that there were no significant differences between the two groups.

The types of explanations given by the nonconserver subjects in the posttest were also investigated. It was found that 43 out of the 60 subjects gave at least one invariant quantity explanation on posttest Form B. On posttest Form C, 53 of the subjects gave at least one invariant quantity explanation. On Form B, 17 subjects out of 60 gave at least one reversibility explanation and on Form C, 9 subjects gave at least one reversibility explanation. Also on Form B, 7 subjects gave at least one compensation explanation and on Form C, 2 subjects gave at least one compensation explanation. For a summary of this data refer to Appendix E.

DISCUSSION

These results have indicated that a nonconserving child will increase in conservation score after hearing conservation judgments and explanations from either other children or adults. Piaget (1926) has suggested that repeated communication conflicts between children are necessary for intellectual development. Piaget has asserted that children are less egocentric with other children than with adults. By egocentric Piaget means the centering of one's viewpoint to the exclusion of other viewpoints. Hence, the child would be more likely to revise his position when discrepant information comes from a child rather than an adult. There have been no studies which investigate the differential effect of adults and peers on the learning of children. Therefore I shall speculate by using Piagetian and other relevant research.

It is well known that Piaget's observations were done to a large degree in natural settings. In natural settings a child is confronted with a mixture of peer and adult figures. Piaget has stated that once a stage in development is passed, all of the conflicts involved in that stage are overcome and equilibrium is restored. Also the concepts which had caused difficulty in the previous stage become matters of little concern and have been assimilated and accommodated to a point where they seem to be "natural" laws in the child's thinking. In other words a child who has recently acquired conservation does not ponder over the conflicts and disequilibrium he or she was faced with in the transition. If this idea is carried further, that is into adult life, these processes of conservation would probably never be thought of as anything but obvious to the adult. The point of this discussion is that perhaps adults are not generally concerned with conservation and therefore would not likely interact with children on that point. Therefore in a natural setting a child would probably only discuss the conflicts of conservation with peers who are experiencing the conflict also. It would seem logical from this that conservation acquisition would most naturally come from interaction with other children.

The present study, however, had nonconserving children interact with adults, who were found to be effective in increasing the nonconservers conservation scores. The conclusion that can be drawn from this discussion is that Piaget is correct in asserting that "communication conflicts between children" are necessary for conservation acquisition, however, this is due mainly to the fact that children do not interact with adults and create "communication conflicts" between adults and themselves when dealing with conservation. Adults are effective in inducing conservation but because this does not happen usually in natural settings it was not observed by Piaget.

How is it that children do in fact increase in conservation score when interacting with adult and peer conservers? Cartwright and Zander (1968) have suggested that when a group is brought together and exposed to the same environment, the group will assume that there is only one correct description of the environment. If one person perceives the environment differently, however, he is faced with cognitive conflict. Cartwright and Zander (1968) have stated:

> "Research such as Asch's suggest that the tendency for a person to accept other opinions when these contradict the testimony of his own senses is stronger the more closely certain conditions are met. (a) The quality of the evidence presented by others is compelling. The existence of unanimity among the others is of crucial importance, but the absolute size of the group appears to make little difference beyond three or four. (b) The stimulus being judged is ambiguous. (c) The subject's confidence in the correctness of his own perception is low. (d) The discrepancy between his own opinion and the opinion of the others is large but not too large. (e) The subject knows that others are aware that his opinion differs from theirs (p. 140)."

Have the above conditions been met in the present study? In all cases the conservers were unanimous in their conserving judgments. It can also be suggested that because both conservers gave similar types of explanations and did so over all six conservation questions, then this would have been experienced as compelling by the nonconserver. Whether or not the stimulus was judged as ambiguous by the nonconservers is not known. Most likely, however, the stimulus was not experienced as being ambiguous as the nonconservers do believe in their nonconservation judgments. A child in the stage of transitional conservation may experience the conservation stimuli as ambiguous because of their vascillation between conservation and nonconservation. It is also not known whether the subject's confidence in the correctness of his own perception was low in these cases. However a child in the stage of transitional conservation would not be expected to be very confident in his answers. In the present study the nonconservers could score up to 5 out of 12 on the pretest form. It would therefore be expected that as the pretest scores increase the amount of confidence in non-conservation answers would decrease.

The discrepancy between the opinion of the nonconservers and conservers in each interaction would seem to be very large. In fact the opinion of the nonconserver was the inverse of the opinions of the conservers. Inhelder and Sinclair (1969) have stated that in order for nonconservers to acquire conservation they must be cognitively ready for it. Therefore in relation to the discrepancy of opinions of nonconservers and conservers the difference may not be as great as it seems. Children who are cognitively ready to acquire conservation may have some of the necessary cognitive ingredients needed for conservation, for instance the ability to count, a rudimentary knowledge of reversibility. This would suggest that the nonconservation opinions of non-conservers are not that discrepant from the conservation opinions of conservers. Murray and Johnson (1969) have found that children do in fact have knowledge of reversibility before they acquire conservation. Also children in kindergarten and grade one are taught to count and use numbers.

Finally because the judgments and explanations were verbalized the nonconservers knew that the conservers were aware of their opinions. Therefore it can be seen that the present procedure did at least partially follow the conditions stated by Cartwright and Zander.

It could be suggested that the nonconservers conformed to the expectations of the conservers. Kelman (1961) in discussing opinion change suggested two types of conforming. An informational influence is where the person conforms to the influencing person or group because he views him as a source of valid information. A normative influence is when the person conforms in order to meet the positive expectations of the influencing person or group. In the present study it is felt that the informational influence was the most important. This is because firstly the nonconservers had to answer conservation questions which were not similar to the questions used during the interaction (Form C) and secondly the nonconservers were posttested alone. If it had been a normative influence the nonconserver would have been expected to revert back to nonconservation in the posttest because he was alone and presented with dissimilar questions.

Patel and Gorden (1960) have stated that a suggestion is normative when it represents a response that is characteristic of a group. Therefore normative influence is similar to social pressure. Was social pressure an influence in the outcome of this study? The answer would seem to be no. Patel and Gorden (1960) in a review of the literature on yielding to influence state that "the studies provide little evidence that subjects change their attitudes sufficiently for there to be a change in their overt behaviour outside the experimental situation" (P. 411). Luchins and Luchins (1955) report that on re-test without social pressure, all their subjects gave objectively correct responses or in other words went back to their original opinions. In the present study the nonconservers were posttested individually and given a generalizability form (C). Therefore social pressure does not seem to be a factor involved in the increase in conservation score in the present study.

The second area of concern of the present study was the effects of hearing the different types of conservation explanations on the conservation score of nonconservers. The results of the present study suggest that there were no differences.

Brainerd and Allen (1971) in a review of studies of experimental inductions of conservation conclude that all successful studies in the induction of conservation made use of treatments that specified reversibility. Therefore the finding of the present study that the use of invariant quantity explanations was as effective as either reversibility or compensation in increasing conservation score deserves note. It may be that knowledge of invariant quantity is sufficient for nonconservers to acquire conservation or possibly as Piaget (1964) has suggested, the nonconserving subjects had a rudimentary knowledge of reversibility or compensation and therefore the added information of invariant quantity was enough to aid them in acquiring conservation. This, unfortunately, cannot be answered by the present study.

Brainerd (1972) designed a study to address the issues of the effectiveness of simple contingent reinforcement in the induction of conservation concepts in previously nonconserving children and the role of reversibility in conservation acquisition. The results suggest that the experimentally induced conservers used reversibility more frequently and compensation less frequently than did natural conservers.

In order to study this, the types of explanations given by the nonconservers on the posttest in the present study were investigated. As was suggested in the results section and summarized in Appendix E, by far the most common type of explanation was that of invariant quantity regardless of whether or not invariant quantity explanations were heard by the subjects.

Brainerd (1972) suggests that reversibility is developmentally prior to compensation. The present study suggests that invariant quantity may be developmentally prior to both reversibility and compensation. Since Form C is the generalization form it would seem to be the best indicator of which explanation is the easiest for the subject to use and understand. Once again invariant quantity is used by many more subjects than the other two types.

Finally some attention should be paid to the relevance of the present study to education. The present study supports the notion that children may be as effective in stimulating some forms of cognitive growth in nonconservers as are adults. Therefore it would seem that a classroom where both adult interaction and peer interaction is available would be the most beneficial. The "open" classroom concept which has become popular over the past few years should produce the type of environment which allows adult and peer interaction to take place.

The results of the present study may also suggest that the conserving children were "little teachers". This would assume that the nonconservers learned through an instructional format which is common to our school system.

Assuming that the acceleration of cognitive growth is permanent, one interesting question that must be studied is whether this acceleration has any long range effects on children. In other words, if a child is trained in an advanced cognitive concept (i.e., conservation) will that training effect the speed at which the child develops other cognitive concepts? For example, will a child who acquires the conservation of substance and weight early also acquire conservation of volume early? A longitudinal study would be necessary for any research such as this. The results would be significant in that they would answer the question of whether or not acceleration in cognitive development has any lasting effect?

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Appendix A

Form A,B, and C, of the Concept Assessment Kit-Conservation.

43

CONCEPT ASSESMENT KIT- CONSERVATION

Marcel L. Goldschmid and Peter M. Bentler

RECORDING FORM
FORM A

SCORES

Task	Behavior	Explanation	Total
A			
B			
C			
D			
E			
F			
Total			

NAME ____________ DATE ____________

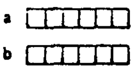
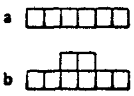
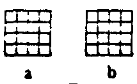
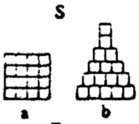
DATE OF BIRTH ____________ AGE ____________ SEX ____________

SCHOOL ____________ GRADE ____________

EXAMINER ____________

COMMENTS ____________

(A) TWO-DIMENSIONAL SPACE

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 equal lines S  E	*Build 2 lines, each with 6 blocks of wood, saying:* *When finished ask:* *If the subject says they are both the same, say: And go on to (II)* *If he says they are not the same, say:* *Demonstrate to subject by pointing that they are the same, then, when S agrees, go on to (II)*	**Watch what I do.** **Is there as much wood here* as there or does one have more?** **Yes, they are both the same.** **Look. This one is just as big as that one. See, they are both the same.**		
II. 2 unequal lines S  E	*Take 2 additional blocks, saying:* *Then, say:* *Record. Then ask:* *Record, and say:*	**Look. I am putting these blocks here.** **Now tell me. Is there as much wood here as there, or does one have more?** **Why?** **O.K. Let's do something else.**	Same ☐ a has more ☐ b has more ☐	
III. 2 equal squares S  E	*Build 2 squares with 16 pieces of wood each, saying:* *When finished, ask:* *If the subject says they are the same, continue with (IV).* *If the subject says they are not the same, say:* *Demonstrate to subject by pointing that they are the same, then, go on to (IV)*	**Watch what I do.** **Is there as much wood here as there, or does one have more?** **Look. This one is just as big as that one. See, they are both the same.**		
IV. square vs. pyramid S  E	*Then, take the blocks from the right square and build a pyramid with a base of 5 blocks and successive levels of 4, 3, 2, 1 and 1 blocks, saying:* *When finished, ask:* *Record, then ask:* *Record.*	**Watch what I do.** **Now, is there as much wood in this one as in that one, or does one have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	____ ____

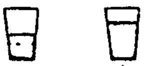
*When saying the first underlined word, point to (a); when saying the second underlined word, point to (b). Follow this procedure for all underlined words.

(B) NUMBER

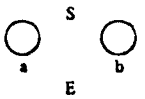
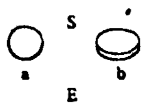
ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. parallel red and white chips S a O O O O O O b O O O O O O E	*Place 6 red chips in a straight line about 4 inches apart. Parallel to and below the red chips, place 6 white chips in corresponding position, also in a straight line, saying:* *When finished, say:* *If subject says there are as many red as white chips go on to (II)* *If he says one line has more than the other, say:* *Demonstrate to subject by pointing that they are the same, then, when he agrees, go on to (II)*	Watch what I do. Are there as many red chips as white chips or are there more red chips than white chips? No, look. There is one red chip for every white chip. Do you see now that there are as many red chips as white chips?		
II. red vs white chips S a OOOOOO b O O O O O O E	*Leave the two lines of chips in a horizontal position, one line below the other, but spread out the white chips (6 inches apart), and move the red chips closer together (2 inches apart), saying:* *When finished, ask:* *Record, and ask:* *Record.*	Watch what I do. Now, are there as many red chips as white chips, or is there more of one kind? Why?	Same ☐ a has more ☐ b has more ☐	____ ____

(C) SUBSTANCE

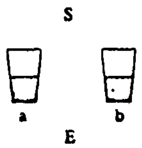
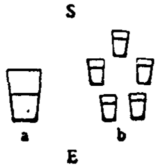
ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 equal balls S  a b E	*Make two equal balls of play doh (each 3 oz.), saying:* *If the subject says they are both the same, go on to (II)* *If the subject says one ball is larger, say:* *Continue to adjust the two balls until the subject says they are the same.*	Here are two balls of play doh. There is the same amount of play doh in each ball. They are both alike. Is there as much play doh in this ball as in that one, or does one have more? Let's make them the same. I am taking a little bit away from this one and adding it to that one. Now, is there as much play doh in this one as in that one?		
II. ball vs. hotdog S  a b E	*Roll one ball into a hotdog (6 inches long – use ruler), saying:* *When finished, ask:* *Record, and ask:* *Record.*	Now watch what I do. See, I am making this ball into a hotdog. Now, is there as much play doh in this one, as in that one, or does one have more? Why?	Same ☐ a has more ☐ b has more ☐	____ ____

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 equal large glasses S  a b E	*Place the two large glasses filled with an equal amount of water (150 ml) before the child, and say:* *Then, ask:* *If the subject says they both have the same amount, go on to (II)* *If the subject says one has more, adjust the water level, saying:* *Then, ask:* *Continue to adjust the water in the two glasses until he says that they both have the same.*	See, here are two glasses both filled with the same amount of water. Is there as much water in this glass as in that one, or does one have more? Let's make them the same. See, I am pouring a little from this glass into that one. Now, is there as much water in this one as in that one or does one have more?		
II. 2 unequal glasses S  a b E	*Pour 25 ml of water from an extra glass into the large glass at right, remove the extra glass, but leave it on the table, saying:* *Then ask:* *Record, and ask:* *Record.*	Watch what I do. See, I am pouring a little water from this glass into that one. Now, is there as much water in this glass as in that one, or does one have more? Why?	Same ☐ a has more ☐ b has more ☐	
III. large glass vs. dish S  a b E	*Pour water from right glass (which has more water) into the flat dish, saying:* *When finished, ask:* *Record, and ask:* *Record.*	Watch what I do. Now, does this one have as much water as that one, or does one have more? Why?	Same ☐ a has more ☐ b has more ☐	
IV. 2 large glasses S  a b E	*Place the two large glasses filled with an equal amount of water (150 ml) before the child, and say:* *Then, ask:* *If the subject says they both have the same amount, go on to (V).* *If the subject says one has more, adjust the water level, saying:* *Then, ask:* *Continue to adjust the water in the two glasses until he says they both have the same.*	See, here are two glasses both filled with the same amount of water. Is there as much water in this glass as in that one, or does one have more? Let's make them the same. See, I am pouring a little from this glass into that one. Now, is there as much water in this glass as in that one, or does one have more?		
V. large glass vs. dish S  a b E	*Pour the water from right glass into the dish, saying:* *Remove empty glass, but leave it on the table, and ask:* *Record, and ask:* *Record.*	Watch what I do. Is there as much water in this one as in that one, or does one have more? Why?	Same ☐ a has more ☐ b has more ☐	____ ____

(E) WEIGHT

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 equal balls 	*Make two equal balls of play doh (each 3 oz.), saying:* *Give the balls to the child, and say:* *(Be sure that the subject picks up the balls and weighs them in his hands.)* *If the child says they weigh the same, go on to (II).* *If the subject says one weighs more, say:* *Give balls back to subject and ask:* *Continue to adjust the two balls until he says they weigh the same.*	**Here are two balls of play doh. One ball is as heavy as the other ball.** **Is one ball as heavy as the other, or is one ball heavier than the other?** **Let's make them the same. I am taking a little bit away from this one and adding it to that one.** **Now are they the same? Is one ball as heavy as the other?**		
II. ball vs. pancake 	***Make the right ball into a pancake. Flatten the ball until the diameter is 4 inches (use ruler), saying:*** ***When finished, ask:*** ***(Do not allow the subject to pick up the ball or pancake)*** ***Record, and ask:*** ***Record.***	**Watch what I am doing. See, I am making one of the balls into a pancake.** **Now, is the <u>ball</u> as heavy as the <u>pancake</u>, or is one heavier?** **Why?**	Same ☐ a has more ☐ b has more ☐	____ ____

(F) DISCONTINUOUS QUANTITY

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 large glasses 	***Place the two glasses, filled with an equal amount of corn (150 ml), in front of the child, saying:*** ***(Level the surface in both glasses.)*** ***If the subject says they both have the same, go on to (II).*** ***If the subject says one has more, say:*** ***Continue to adjust the corn in the two glasses, until he says they both have the same amount.***	**See, here are two glasses both filled with the same amount of corn. Is there as much corn in <u>this</u> glass as in <u>that</u> one, or does one have more?** **Let's make them the same. See, I am pouring some corn from this glass into that one. Now, is there as much corn in <u>this</u> one as in <u>that</u> one, or does one have more?**		
II. large glass vs. 5 small glasses 	***Pour the corn from the large glass into the small glasses (arranged in a circle, close together) in equal amounts, saying:*** ***When finished, ask:*** ***Record, then ask:*** ***Record.***	**Watch what I do. See, I am pouring the corn from this glass into all of these glasses.** **Now, is there as much corn in <u>this</u> one as in all of <u>these</u> together, or does one side have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	____ ____

CONCEPT ASSESSMENT KIT—CONSERVATION

Marcel L. Goldschmid and Peter M. Bentler

RECORDING FORM
FORM B

SCORES			
Task	Behavior	Explanation	Total
A			
B			
C			
D			
E			
F			
Total			

NAME ____________________ DATE ____________

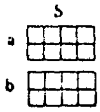
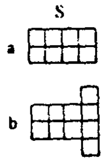
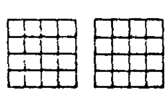
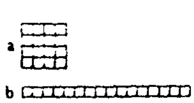
DATE OF BIRTH ____________ AGE ________ SEX ____________

SCHOOL ____________________ GRADE ____________

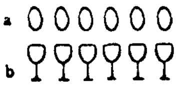
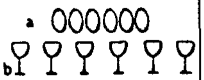
EXAMINER ____________________

COMMENTS ____________________

(A) TWO-DIMENSIONAL SPACE

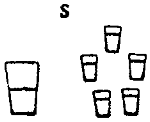
ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 equal rectangles S  E	*Build 2 rectangles, each with 8 blocks of wood, saying:* *When finished, ask:* *If the subject says they are both the same, say: and go on to (II).* *If he says they are not the same, say:* *Demonstrate to subject by pointing that they are the same, then, when S agrees, go on to (II).*	**Watch what I do.** **Is there as much wood <u>here</u>* as <u>there</u>, or does one have more?** **Yes, they are both the same.** **Look. <u>This</u> one is just as big as <u>that</u> one. See, they are both the same.**		
II. 2 unequal rectangles S  E	*Take 2 additional blocks, saying:* *Then, say:* *Record. Then ask:* *Record, and say:*	**Look. I am putting these blocks here.** **Now tell me. Is there as much wood <u>here</u> as <u>there</u>, or does one have more?** **Why?** **O.K. Let's do something else.**	Same ☐ a has more ☐ b has more ☐	
III. 2 equal squares S  E	*Build 2 squares with 16 blocks of wood each, saying:* *When finished, ask:* *If the subject says they are the same, continue with (IV).* *If the subject says they are not the same, say:* *Demonstrate to subject by pointing that they are the same, then, go on to (IV).*	**Watch what I do.** **Is there as much wood <u>here</u> as <u>there</u>, or does one have more?** **Look. <u>This</u> one is just as big as <u>that</u> one. See, they are both the same.**		
IV. square vs. single line S  E	*Then, take the blocks from the right square and build a single line with all 16 blocks, saying:* *When finished, ask:* *Record, then ask:* *Record.*	**Watch what I do.** **Now, is there as much wood in <u>this</u> one as in <u>that</u> one, or does one have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	

*When saying the first underlined word, point to (a), when saying the second underlined word, point to (b). Follow this procedure for all underlined words.

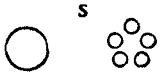
ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. Parallel egg-cups & eggs S  E	*Place 6 egg cups in a straight line about 4 inches apart. Parallel to these, stand 6 eggs in corresponding position, also in a straight line, saying:* *When finished, say:* *Remove eggs from cups.*	Watch what I do. Now, I want you to put each one of these eggs into the egg cup next to it.		
II. eggs vs. egg-cups S  E	*Restore the two lines of eggs and cups, but spread out cups (6 inches apart) and move eggs closer together (2 inches apart), saying:* *Then, ask:* *Record, then ask:* *Record.*	Watch what I do. Now, are there as many eggs as cups or are there more of one kind? Why?	Same ☐ a has more ☐ b has more ☐	—— ——

(C) SUBSTANCE

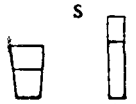
ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 equal balls S  E	*Make two equal balls of play doh (each 3 oz.), saying:* *If the subject says they are both the same, go on to (II).* *If the subject says one ball is larger, say:* *Continue to adjust the two balls until the subject says they are the same.*	Here are two balls of play doh. There is the same amount of play doh in each ball. They are both alike. Is there as much play doh in this ball as in that one, or does one have more? Let's make them the same. I am taking a little bit away from this one and adding it to that one. Now, is there as much play doh in this one as in that one?		
II. ball vs. pancake S  E	*Flatten one ball into a pancake (4 inches in diameter – use ruler), saying:* *When finished, ask:* *Record, and ask:* *Record.*	Watch what I do. See, I am making this ball into a pancake. Now, is there as much play doh in this one as in that one, or does one have more? Why?	Same ☐ a has more ☐ b has more ☐	—— ——

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I. 2 large glasses S  a b E	*Place the two large glasses filled with an equal amount of water (150 ml) before the child, saying:* *Then, ask:* *If the subject says they both have the same amount, go on to (II).* *If the subject says one has more, adjust the water level, saying:* *Then, ask:* *Continue to adjust the water in the two glasses until he says that they both have the same.*	**See, here are two glasses both filled with the same amount of water.** **Is there as much water in <u>this</u> glass as in <u>that</u> one, or does one have more?** **Let's make them the same. See, I am pouring a little from this glass into that one.** **Now, is there as much water in <u>this</u> one as in <u>that</u> one or does one have more?**		
II. 2 unequal glasses S.  a b E	*Pour 25 ml of water from an extra glass into large glass at right, remove the extra glass, but leave it on the table, saying:* *Then, ask:* *Record, and ask:* *Record.*	**Watch what I do. See, I am pouring a little water from this glass into that one.** **Now, is there as much water in <u>this</u> glass as in <u>that</u> one, or does one have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	
III. large glass vs. 5 small glasses S  a b E	*Pour water from the large glass (which has more water) into the five little glasses, saying:* *When finished, ask:* *Record, and ask:* *Record.*	**Watch what I do.** **Now, does <u>this</u> glass have as much water as <u>these</u> glasses together, or does one side have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	
IV. 2 equal large glasses S  a b E	*Place the two large glasses filled with an equal amount of water (150 ml) before the subject, saying:* *Then, ask:* *If the subject says they both have the same amount, go on to (V).* *If the subject says one has more, adjust the water level, saying:* *Then, ask:* *Continue to adjust the water in the two glasses until he says they both have the same.*	**See, here are two glasses both filled with the same amount of water.** **Is there as much water in <u>this</u> glass as in <u>that</u> one, or does one have more?** **Let's make them the same. See, I am pouring a little from this glass into that one.** **Now, is there as much water in <u>this</u> glass as in <u>that</u> one, or does one have more?**		
V. large glass vs. 5 small glasses S  a b E	*Pour the water from the large glass into the five small glasses, saying:* *Remove empty glass, but leave it on the table, and ask:* *Record, and ask:* *Record.*	**Watch what I do.** **Is there as much water in <u>this</u> glass as in all <u>these</u> together, or does one side have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	____ ____

WEIGHT

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I 2 equal balls S  a b E	*Make two equal balls of play doh (each 3 oz.), saying* *Give the balls to the child and say* *(Be sure that the subject picks up the balls and weighs them in his hands.)* *If the child says they weigh the same, go on to (II).* *If the subject says one weighs more, say* *Give ball back to subject and ask* *Continue to adjust the two balls until he says they weigh the same.*	**Here are two balls of play doh One ball is as heavy as the other ball** **Is one ball as heavy as the other, or is one ball heavier than the other?** **Let's make them the same I am taking a little bit away from this one, and adding it to that one.** **Now are they the same, is one ball as heavy as the other?**		
II. ball vs. 5 little balls S  a b E	*Make the right ball into 5 little balls of approximately the same size, and arrange them in a circle, saying* *When finished, ask* *(Do not allow the subject to pick up the balls.)* *Record, and ask:* *Record.*	**Watch what I am doing I am going to make little balls out of this ball.** **Now, is this ball as heavy as all these balls together or is one side heavier?** **Why?**	Same ☐ a has more ☐ b has more ☐	___ ___

(F) DISCONTINUOUS QUANTITY

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
I 2 equal large glasses S  a b E	*Place the two glasses, filled with an equal amount of corn (150 ml), in front of the child, saying.* *(Level the surface in both glasses.)* *If the subject says they both have the same, go on to (II)* *If the subject says one has more, say* *Continue to adjust the corn in the two glasses until he says they both have the same amount, before going on to (II).*	**See, here are two glasses both filled with the same amount of corn. Is there as much corn in this glass as in that one, or does one have more in it?** **Let's make them the same See, I am pouring some corn from this glass into that one. Now, is there as much corn in this one as in that one or does one have more?**		
II. large glass vs. tall glass S  a b E	*Pour the corn from the large glass into the tall glass, saying* *When finished, say:* *Record, and ask:* *Record.*	**Watch what I do. See, I am pouring the corn from this glass into that one.** **Now, is there as much corn in this one as in that one, or does one have more?** **Why?**	Same ☐ a has more ☐ b has more ☐	___ ___

CONCEPT ASSESSMENT KIT—CONSERVATION

Marcel L. Goldschmid and Peter M. Bentler

RECORDING FORM
FORM C

SCORES			
Task	Behavior	Explanation	Total
A I			
A II			
A III			
B I			
B II			
B III			
Total			

NAME ______________________ DATE ______________

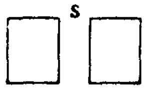
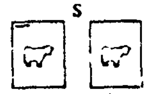
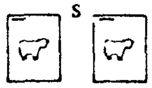
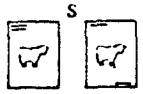
DATE OF BIRTH ______________ AGE ________ SEX ______________

SCHOOL ______________________ GRADE ______________

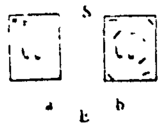
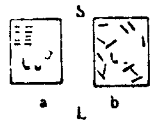
EXAMINER ______________________

COMMENTS ______________________

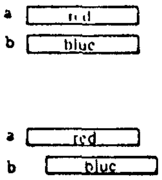
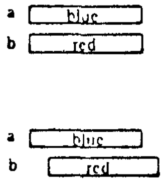
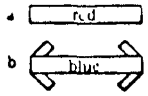
(A) AREA

ITEM	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
(a) Presentation of boards S  a b E	*Place the 2 boards before S with the long sides parallel, about 2 inches apart, saying:* *Superimpose the boards for a moment, saying:* *Then, replace boards as before.*	Let's pretend that these boards are two fields of grass. See, they are the same size.		
(b) 1 cow in each field, 1 barn in left field S  a b E	*Place one cow in the center of each board, saying:* *Place a barn on left field, 2 inches from upper left corner, saying:* *Then, ask:* *Depending on subject's response, say:*	If we put a cow in each field, each cow has just as much grass to eat as the other cow. Now, Farmer Jones builds a barn on this* field. He has to take some of the grass away to make room for the barn. Now, show me which cow has more grass to eat. Yes (or no), that *(point to b)* cow has more grass to eat, because the barn covers up part of this cow's grass.		
(c) 1 cow in each field 1 barn in each field S  a b E	*Hand a barn to S, saying:* *Give help if necessary, then, say:*	Take this barn, and put it in the field so this cow has just as much grass to eat as that one. Now, every time I put a barn in one field, I will also put a barn in the other field.		
I 2 barns vs. 2 barns S  a b E	*Taking up a barn in each hand, place a second barn in each field. On the left board, put second barn close beside first one. On right board put second barn in diagonally opposite corner from the first, saying:* *When finished, ask:* *Record, and ask:* *Record.*	Watch what I do. Now, does this cow have just as much grass to eat as that one, or does one have more grass to eat? Why?	Same ☐ a has more ☐ b has more ☐	

*When saying the first underlined word, point to (a), when saying the second underlined word, point to (b). Follow this procedure for all underlined words.

	DIRECTIONS	VERBAL INSTRUCTIONS	RESPONSE	SCORE
II 6 vs 6 barns 	*Place 4 barns, one at a time on each board simultaneously picking up one with your left, and one with your right hand. On left board, place barns next to each other in two rows of 3 barns each. On right board, scatter barns over entire area except near edges, as in graph, saying* *When finished, ask:* *Record, and ask:*	**Watch what I do. You see, I am putting some more barns in each field.** **Now, does this cow have as much grass to eat as that one, or does one have more grass to eat?** **Why?**	Same ☐ a has more ☐ b has more ☐	
III 12 vs 12 barns 	*Place 6 more barns in each field, following the same procedure as in item (II), saying:* *When finished, ask:* *Record, and ask*	**Watch what I do. I am putting some more barns in each field.** **Now, does this cow have as much grass to eat as that one, or does one have more grass to eat?** **Why?**	Same ☐ a has more ☐ b has more ☐	

(B) LENGTH

I blue vs red stick 	*Present the blue and red stick to the subject making sure that he sees that they are of equal length, that the 2 ends at both sides correspond, saying* *Then, put them parallel to each other in front of the child. Move the blue stick by one inch to the right, and say:* *Record, and ask:* *Record.*	**You see these two sticks, they are both the same length. Is the red stick as long as the blue stick, or is it longer or shorter?** **Now, is the red stick as long as the blue stick, or is it longer or shorter?** **Why?**	Same ☐ a is longer ☐ b is longer ☐	
II red vs blue stick 	*Put the sticks again parallel to each other and make sure the S can see that they are of identical length.* *Then, move the red stick to the right by one inch, and ask* *Record, and ask:* *Record.*	**Now, is the blue stick as long as the red stick, or is it longer or shorter?** **Why?**	Same ☐ a is longer ☐ b is longer ☐	
III blue stick with arrow vs red stick 	*Put the sticks again parallel to each other, and show him that they are of equal length. Then, put the blue stick between the arrowheads, so that the points of the arrows are exactly superimposed on the ends of the stick, ask.* *Record, and ask:* *Record.*	**Watch what I do.** **Now, is the red stick as long as the blue stick, or is it longer or shorter?** **Why?**	Same ☐ a is longer ☐ b is longer ☐	

Appendix B

Training of conservers in the use of both the reversibility and compensation concepts.

Appendix B

When training reversibility pennies were also used (as in the training of invariant quantity). The pennies were changed into many different shapes and forms. What was stressed in this case was that no matter what shape the row of pennies took they could always be changed back the way they were.

The training of compensation was very similar except that in this case when using the pennies it was noted that the distance between the pennies had changed. For instance when the pennies in one row were spread out further than the other it was stressed that they were still the same because one row had small spaces and one row had larger spaces.

APPENDIX C

There was a significant effect on the Forms of the Concept Assessment Kit - Conservation ($p < .05$). There was found to be no significant effect on conservation scores of nonconservers when hearing conservation judgments from either conserving adults or conserving peers ($p > .05$). Also there was no significant effect on the conservation scores of nonconservers over the types of explanations given by the conservers ($p > .05$). Finally there were no interaction effects on Conservers X Explanations, Conservers X Forms of Kit, Explanations X Forms of Kit, and Conservers X Explanations X Forms of Kit ($p > .05$).

Appendix C

Summary of Analysis of Variance of Type of Conserver, Type of Explanation, Forms of Concept Assessment Kit (Form A - Pretest, B - Posttest, C - Posttest) using Scores on Kit as Dependent Variable.

Source	Ss	df	M.S.	F
Between Subjects	1060.06	59		
Conservers	44.00	1	44.00	2.77
Explanations	77.68	2	38.68	2.44
Conservers X Explanations	81.08	2	40.54	2.55
Subjects Within Group	857.30	54	15.88	
Within Subjects	2047.00	120		
Forms of Kit	1312.58	2	656.29	108.30*
Conservers X Forms	34.45	2	17.23	2.84
Explanations X Forms	38.15	4	9.54	1.57
Conservers X Forms X Explanations	6.82	4	1.71	< 1.00
Forms X Subject Within Group	655.00	108	6.06	

*significant at alpha = .01

Appendix D

Nonconserving children hearing conservation judgments from both adults and peers give significantly more conservation judgments and explanations on Form B and C than on Form A ($p < .05$). Also these children give significantly more conservation judgments and explanations on Form B than on Form C ($p < .05$).

Appendix D

Summary Table - Newman-Keuls Analysis of Conservation Scores of the Form of the Kit. Main Effect as Shown in Summary Table 1.

$(X_j - X_i) = qr \frac{\text{M.S. within}}{N}$ qr (3,108) = 3.36 M.S. = 6.06

qr (2,108) = 2.80 N = 60

$(X_j - X_i) = 1.08$ (critical difference at r = 3)

$(X_j - X_i) = 0.90$ (critical difference at r = 2)

Pretest (A) = 1.68

Posttest B (B) = 7.95

Posttest C (C) = 6.65

	A	C	B
	1.68	6.65	7.95
A - 1.68		4.97*	6.27*
C - 6.65			1.30*
B - 7.95			

*significant at the 0.05 level of confidence.

Appendix E

Subjects in the posttests use invariant quantity explanations more than reversibility explanations. They also use reversibility explanations more than compensation explanations.

Appendix E

Summary Table - Number of Subjects Using Different Explanations in Each Experimental Group.

Group	No. of Ss using at least 1 IQ explanation		No. of Ss using at least 1 R explanation		No. of Ss using at least 1 C explanation	
	Form B	Form C	Form B	Form C	Form B	Form C
A - IQ	10	10	0	0	0	0
A - R	6	9	8	4	0	0
A - C	8	9	0	0	3	2
Total	24	28	8	4	3	2
P - IQ	7	10	0	0	0	0
P - R	6	8	9	4	0	0
P - C	6	7	0	1	2	0
Total	19	25	9	5	2	0