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AN INVESTIGATION WAS UNDERTAKEN TO EXPLORE THE INSTRUCTIONAL IMPLICATIONS OF JEAN PIAGET@S POSITION ON EQUILIBRATION. ONE PURPOSE WAS TO TEST THE GENERAL HYPOTHESIS THAT THE MISCONCEPTIONS OF CHILDREN, WHEN DISPLACED BY EVIDENCE CONTRARY TO THE MISCONCEPTIONS, GIVE RISE TO COGNITIVE CONFLICTS. THE RESULTS, IN GENERAL, CONFIRM THIS HYPOTHESIS. A SECOND PURPOSE WAS TO EXPLORE THE MEANS BY WHICH COGNITIVE CONFLICTS ARE PRODUCED. IN THIS REGARD, EMPHASIS WAS ON TECHNIQUES READILY ADAPTABLE TO THE INSTRUCTIONAL SITUATION. FEIGNED SURPRISE WAS SUCH TECHNIQUE WHICH PROVED EFFECTIVE. ONE OF THE MORE STRIKING OUTCOMES OF THE STUDY WAS THE EXTENT TO WHICH BOYS OUTPERFORMED GIRLS IN CONSTRUCTIVELY RESOLVING COGNITIVE CONFLICTS. A SECOND PHASE OF THE STUDY WAS LARGELY EXPLORATORY. IT FOCUSED ON THE IDENTIFICATION OF NONCONSTRUCTIVE FORMS OF CONFLICT RESOLUTION AMONG CHILDREN. (JC)

HOW ELEMENTARY SCHOOL CHILDREN RESOLVE EXPERIMENTALLY PRODUCED CONFLICTS IN THINKING

COOPERATIVE RESEARCH PROJECT NO. 3216

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INTRODUCTION

The studies reported here are part of a program of research exploring the instructional implications of Jean Piaget's genetic-epistemological position. Piaget and his group at Geneva have developed an enormous body of knowledge about the conditions which contribute to cognitive development among children. The explicit intent of this study has been to look to this body of knowledge, and to extensions of it, for variables which may be amenable to manipulation in the instructional setting.

Numerous studies report attempts to accelerate the child's attainment of complex number- and science-related concepts. Recently, a method has been developed which has been both successful and soundly founded in theory, while at the same time holding considerable promise for wide applicability. Briefly, this method consists of the experimental inducement of cognitive conflicts. One means by which this may be accomplished is to make use of knowledge of the individual's misconceptions, and to introduce events which, when coupled with these misconceptions, give rise to contradictions. Such conflicts may prompt cognitive reorganization, whereby earlier, mistaken conceptions are displaced and new concepts are attained. Not all forms of conflict resolution may be so constructive, however.

Individuals may often resort to various forms of pseudo-explanation, deny or fabricate data, or plead ignorance.

If the cognitive progress of children may be accelerated through their resolution of cognitive conflicts, then we need to know by what various means such conflicts may be produced. Moreover, if the cognitive progress of some children is impeded by nonconstructive forms of conflict resolution, then we need to identify these forms so that, hopefully, we may train children to avoid them.

The present study is a report of two investigations related to these problems. The first explores the effectiveness of three different procedures for producing cognitive conflicts. Each of these three is designed to prompt first-grade children to attain the concept of conservation of number. The second investigation has three purposes. The first is to explore the effectiveness of a conflict-producing event in prompting first-grade children to discard a more obvious, but irrelevant, variable in a situation, and to consider alternative variables which are less obvious. The second is to identify nonconstructive modes of conflict resolution occurring both with this and with a second conflict-producing event, which is considerably more difficu for first-grade children to resolve constructively. The third purpose is to compare the relative incidence of various modes of conflict resolution occurring between two groups of first-grade children that differ on certain social and intellectual background characteristics.

BACKGROUND OF THEORY AND RELATED RESEARCH

An Interpretation of Piaget's Equilibration Position

Since the present study is based largely upon an interpretation and extension of the genetic-epistemological position of Jean Piaget, certain relevant conceptions from his position will be reviewed briefly. Particular emphasis will be placed on that aspect of his position concerned with the equilibration process. According to Piaget (10), assimilation and accommodation are the invariant functions in the process of adaptation. The process of cognitive adaptation involves the assimilation of the externally given to the individual's preexisting cognitive structure, and the accommodation of the preexisting structure to that which is being assimilated. In this view, increasing differentiation of the cognitive structures arises through a succession of equilibrations between assimilation and accommodation. Robert S. Woodworth provides an instructive example of assimilation and accommodation:

> A child on first seeing a squirrel called it a "funny kitty." The new was assimilated to to the old--yet not completely since the new animal was "funny" (15, p. 469).

Let us place this instance in developmental perspective, following Piaget's position. At a somewhat earlier level, the child may have detected no discrepancy between his concept of 'kitty' and his perceived attributes of the squirrel. He may have called the squirrel simply "kitty." In the absence of such discrepancy, the child would be said to have attained equilibrium between assimilation and accommodation, but at a very low level of conceptual differentiation. Assumedly, the somewhat older child of Woodworth's anecdote first detected a discrepancy between his preexisting concept of 'kitty' and his perceived attributes of the referent, and in order to reconcile this discrepancy modified the reference category to 'funny kitty,' a category which for him would accommodate the referent. As at the earlier level, the child may again be said to have attained equilibrium, but at a new level, associated with greater conceptual differentiation. Still later, and at least in part through further equilibrations, more complete differentiations may occur.

Some aspects of this position may now be summarized. First, the position holds that there are many end states to the equilibration process. This is to say that there are many possible levels of equilibrium. Secondly, since each successive end state represents a higher level of cognitive differentiation, it corresponds to a higher level of attainment. Thus, the position holds not that a fully adequate, veridical conceptualization will result from each equilibration, but, rather, that complex concepts may be attained by successive approximations. Each successive equilibration is viewed here as the end state of a process consisting of several arbitrarily distinguishable phases. The starting point may be no more than the vague impression that something is amiss, or it may involve an outright contradiction. The effect of either is to produce a state of disequilibrium, or conflict. This is held to be an aversive state, which may lead, either through further inquiry or directly, to cognitive reorganization. This reorganization results in increased cognitive differentiation. In that this reorganization resolves the initial conflict, it also results in a new level of equilibrium. The inquiry phase of this process may be clarified in terms of the earlier illustration. It would represent any attempt the child might make to secure additional information about the referent that could be of use in satisfactorily categorizing it.

This process is general, applying not only to the construction and modification of simple reference categories, but also to the construction of more complex concepts or principles. For instance, Inhelder and Piaget (8) studied the course of attainment of the law of floating bodies, and concluded that in order for the subject to construct it empirically he first has to eliminate a series of contradictions. Piaget's account of the mechanisms involved in the "normal" acquisition of such highly general concepts and principles serves as a common reference for a rapidly increasing number of studies, all exploring ways to accelerate the cognitive progress of children.

Investigations Related to the Equilibration Position

Among the misconceptions characteristic of children at an early level of development are those concerning the effects of deformations performed on objects or sets of objects. For instance, they may fail to realize that the amount of substance contained in an object is invariant, or conserved, under deformations of the object. Similarly, they may fail to conserve the properties of weight, number, length, surface area, and the like, when objects or sets of objects are deformed.

Jan Smedslund was the first to explore the effectiveness of experimentally-produced cognitive conflicts in prompting children to attain conservation concepts (12; 13). By this means he succeeded, in the absence of external reinforcement, in prompting children to attain the concepts of conservation of continuous and discontinuous substance.

In a typical test of conservation of continuous substance, one of two balls of plasticine, or clay, which the child has agreed to contain the same amount, is rolled out, in full view of the child, into the elongate form of a sausage. The child is asked whether it now contains more, the same amount, or less clay than the ball. Piaget's position is that the nonconserver "centers" on, or takes into account, only one dimension of the deformed object. Thus, if he notices only that it is longer, he will say it contains more, while if he notices only that it is thinner, he will say it contains less. Piaget also holds that the child may attain conservation when the schema of addition/subtraction becomes dominant over these misleading figural cues. That is, the child may come to hold that since no clay was added or taken away, the amount must be the same.

Smedslund's procedure for producing cognitive conflicts followed from Piaget's interpretation. It consisted of prompting nonconservers, whose mistaken conclusions were presumably based on figural cues, to bring the addition/subtraction schema to bear. His position was that taken jointly the figural cues and the addition/subtraction schema would give rise to contradictory conclusions, but that after the child brought the latter to bear, it would eventually come to be the dominant, or preferred basis of conclusion. Smedslund's procedure was too complicated to review here in detail, but, essentially, it consisted of presenting two objects (or sets of objects), where one of the two was variously deformed over a series of transformations, and repeatedly calling for a comparison of the amounts as small bits of substance were added or taken away from one of the objects. This was intended to prompt the children to bring the addition/subtraction schema to bear in subsequent tests of conservation, involving similar comparisons. While he reports data indicating that children submitted to this procedure out-performed a control group, Smedslund tells us nothing of the children's disposition of the mistaken figurally-based conclusion involved in the contradiction. A frequent comment spontaneously offered by children who are being tested for conservation is illuminating in this regard. They will often say that the two objects or sets of objects really contain the same amount but that they only look different.

The notion that cognitive progress may be prompted by conflict-producing events has been proposed elsewhere by both educators and psychologists alike. Dewey, in 1910, for instance, observed that

> ... the origin of thinking is some perplexity, confusion, or doubt. Thinking is not a case of spontaneous combustion; it does not occur just on "general principles." There is something specific which occasions or evokes it. General appeals to a child (or to a grown-up) to think, irrespective of the existence in his own experience of some difficulty which troubles him and disturbs his equilibrium, are as futile as advice to lift himself by his boot-straps (5, p. 12).

One of the major conclusions emmerated by Humphrey in the conclusory section of his book on thinking is that

> ... <u>A problem is a situation which for some reason appreciably holds up an organism in its efforts to reach a goal.</u> In practice the problem often though not always contains contradictory factors, which have to be reconciled (7, p. 312).

More recently, Berlyne (2), and Piaget and Berlyne (11), have explored conditions and constructs which relate to the equilibration position. Berlyne has sought to extend and relate the Piagetian and Hullian positions. He holds that

> We may reinterpret Piaget's view by regarding what he calls equilibrium as a class of hitherto overlooked sources of drive and reward propelling the learning process that give rise to generalized habits of perception and thought. The drive states that are fomented by disequilibrium arise not out of visceral disturbances or aversive external stimuli, but out of unsatisfactory relations between the subject's own responses. Changes in behavior that remove disequilibrium are ones that avert surprise and uncertainty (2, pp. 370-379).

In a more recent book, Berlyne (3) provides a more extensive treatment of this topic, including a section which treats it in terms of the currently popular concepts of information theory.

Suchman (14), investigating the effects of inquiry training, employed conflict-producing events for the purpose of initiating inquiry among children. While his investigation dealt principally with the transfer of inquiry skills, it did clearly demonstrate the effectiveness of conflict-producing events in prompting inquiry.

The present writer (9) has reviewed some of the instructional implications deriving from Piaget's position on equilibration. Particular emphasis was given to the need for developing instructional materials and procedures capable of prompting inquiry and cognitive reorganization. Two principal means for producing resolvable cognitive conflicts are most often suggested. The first is to provide for direct confrontations between the individuals and the content. However, these encounters should not be haphazard. Rather, they should be carefully structed so as to provide evidence which cannot be assimilated without inquiry and cognitive reorganization. The second is to arrange for communication between individuals who bring different conceptions to bear in considering an event, and consequently arrive at conclusions which must be reconciled by inquiry and cognitive reorganization.

Two experimenters have recently attempted to accelerate the attainment of conservation concepts other than those with which Smedslund dealt, employing adaptations of his procedure. Gruen (6) experimented with the conservation of number. He established two groups, one of which received the conflict treatment, and one of which did not. He further divided each of these groups into two, one of which received pretraining in the discrimination of the concepts of 'number' and 'length,' and one of which did not. In a typical test of conservation of number, first two corresponding rows of objects are presented, then one row is deformed. Gruen held that in comparing the deformed and nondeformed rows, children often refer not to the relative number of objects but to the relative lengths of the rows, and consequently deny that they have the "same." The pretraining was intended to remove this confusion. His results showed significantly greater attainment of conservation of number in the pretraining-plus-conflict group than in the group which received neither pretraining nor conflict. Neither the pretraining alone nor the conflict alone resulted in significant gain.

Beilin (1) provided training in the conservation of number and in the conservation of length using four different procedures, one of the four being an adaptation of an early procedure employed by Smedslund.

This adaptation was not based on the procedure of the study reviewed above, in which Smedslund succeeded in training children on conservation of substance, but on the procedure of an earlier study.

Beilin began with two corresponding sets of objects, then performed a series of deformations on one set, as had Smedslund. However, he did not add to or subtract from either set in any of the states in which it appeared. Recall that it was this addition and subtraction which Smedslund held to be the effective factor in eliciting the addition/subtraction schema, and hence in producing the cognitive conflict. Beilin reports no significant improvement for the conflict group in his study. However, it is possible to devise a procedure more closely corresponding to that which Smedslund employed successfully. Further research is needed in order to determine whether such a procedure, more clearly capable of producing cognitive conflicts, will prompt the attainment of conservation of number and length where Beilin's did not.

PHASE I: THREE CONFLICT-PRODUCING PROCEDURES AND THEIR EFFECTIVENESS IN ACCELERATING THE ATTAINMENT OF THE CONCEPT OF CONSERVATION OF NUMBER.

Problem

The first experiment of the present study deals with three separate procedures for producing cognitive conflicts, and with their effectiveness in accelerating the attainment of the concept of conservation of number among children. There are two main conceptions generally held to underlie the conclusions given by children when they are presented with the test of conservation of number. The nonconserver is held to base his conclusion on the notion that more extended arrays contain a greater number of elements. The attainment of conservation is taken to require both that the addition/subtraction schema be brought to bear, and that it become the dominant, or preferred, basis for conclusion. Bruner (4) considers the effects on categorization of the relative availability of reference categories. He maintains that there is an ordering of reference categories in terms of their accessibility. Similarly, we may assume an ordering of the accessibility of the respective bases for nonconservation and conservation. Bruner (4) also holds that the greater the accessibility of a particular category, the more likely categories which provide a better or equally good fit will be masked. In a like manner, the child's notion that more extended arrays contain a greater number of elements is viewed here as one which may mask the addition/subtraction schema. Accordingly, any contradiction of the conclusion based on the former may increase the availability of the latter, and give rise to conservation. Smedslund's conflict-producing procedure (13) operated more directly to increase the availability of the addition/subtraction schema. Presumably, the practice his subjects received in comparing objects of different shapes as additions and subtractions were being made prompted them to bring the addition/subtraction shema to bear on posttests of conservation, where no additions or subtractions were made.

The three conflict-producing procedures employed in the first experiment are all held to be capable of altering the relative availability of the premises upon which conservation and nonconservation of number are based. To clarify the first of these three procedures, it will be helpful to review the test of conservation of number. Typically, two sets of objects are first presented in corresponding arrangements, so that the child will agree that they contain the same number. This may be referred to as a "noncritical" state of the objects. Then one of the two sets is deformed, and the child is again called upon to compare the number of objects they contain. This state of the objects may be referred to as a "critical" state, in that it provides figural cues which prompt many children to conclude that one set now contains a greater number. Clearly, any number of noncritical states may intervene between an initial, non-critical state and a final, critical state. To arrive at noncritical intervening states, it is necessary to transform both sets simultaneously in such a way as to preserve the correspondence in their arrangements. The first conflict-producing procedure (the Set Effect) will consist of presenting initial nonconservers with an extended series of noncritical states. After each transformation, they will be called upon to compare the number of objects contained in the two sets. The purpose of this procedure is to establish a set, or tendency, to give "same" conclusions following transformations. Then a transformation leading to a critical state will be made. It is intended that jointly these procedures will give rise to competing conclusions, thereby producing a state of cognitive conflict. The result may be to reduce the masking effect associated with the figurally-based conclusion, and thereby to prompt the attainment of conservation. The emphasis on noncritical transformations may in itself contribute to the attainment of conservation. In noncritical transformations, both sets of objects are rearranged, and it is comparatively obvious that the rearrangement results in no change in the number of objects. This concept of conservation under corresponding transformations of the two sets of objects may transfer to the situation in which only one of the two sets is transformed.

The second experimental procedure (the Surprise Effect) is an attempt to produce cognitive conflicts by giving a verbal expression of surprise when the nonconserver of number concludes that the deformed set contains a greater or a smaller number of objects. The corrective influence of others may affect the individual's simple categorizations and his more complex conceptions in a similar manner. With regard to simple categorizations, a child may observe a squirrel and label it "kitty," due to the high availability of that particular category. If another individual were to express surprise, or otherwise indicate to the child that this is not an appropriate categorization, he might select an alternative category not initially so high in availability. Similarly, another individual may express surprise when the nonconserver of number concludes that the deformed set contains a greater or a smaller number of objects. If the child interprets this as a contradiction of his conclusion, he may bring to bear an initially less available basis for conclusion, such as the addition/subtraction schema, and consequently attain conservation.

The third experimental procedure (the Peer Effect) is an attempt to produce conflicts by exposing nonconservers of number to the contradictory conclusions of their Peers who are conservers. This procedure is held to operate in the same way as an expression of surprise. However, where surprise is a more indirect expression of contradiction, exposure to the contrary conclusions of one's peers constitutes a more direct contradiction. One may inquire whether such a situation will create conflicts not only for the nonconservers, but also for the conservers, resulting in change among both. Piaget holds that, in general, higher levels of equilibrium are more stable, implying that they are more resistant to change, than lower levels. Following this position, nonconservers are expected to change more readily than conservers.

Methods

Sample--The Ss were two hundred first-grade children with a mean age of 6-7. They were drawn from two urban schools, serving predominantly families of the middle and (to a lesser extent) lower socioeconomic levels.

Experimental Design--The Ss were randomly assigned to four groups, following a table of random numbers, with the restriction that each group contain equal numbers of boys and girls. Three of these groups received experimental treatments, and the fourth served as a control. Table 1 shows the four groups, as well as the time sequence of pretests, treatments, and posttests administered to each. The purpose of the delayed posttests was to make it possible to evaluate the stability of any changes due to the treatments. This procedure also made it possible to evaluate the extent to which any change following the treatments represented merely pseudo-conservation. For instance,

Table 1

Design of the Experiment

		Immediately Following Treatments	Two Weeks Following Treatments	Two Months Following Treaments
Pretest	Treatment I (Set Effect)	Posttest	Posttest	Posttest
Pretest	Treatment II (Surprise Effect)	Posttest	Posttest	Posttest
Pretest	Treatment III (Peer Effect)	Posttest	Posttest	Posttest
Pretest	Control (Interpolated Activity)	Posttest	Posttest	Posttest

under the Set Effect, it was considered possible for some Ss to come to say "same" in comparing the two sets of objects, but due only to the set to say "same," and not due to the resolution of cognitive conflict. However, it was considered very unlikely that this set would last for two weeks or for two months, especially in light of the fact that on these delayed posttests the figural cues which prompt nonconservation would be present, and would tend to work in opposition to any residual set effect. Similarly, the delayed posttests make it possible to evaluate any pseudo-conservation following the Surprise and Peer Effects, where changes could reflect only conformity to the conclusions implied or expressed by others, and not the attainment of a logically certain and lasting concept of conservation.

Four Es were involved in the administration of the pretests, experimental treatments, and posttests. All tested approximately the same total number of Ss, individually. Moreover, each tested and administered treatments to exactly the same number of Ss in each of the four groups (with the exception of the Peer Effect group, in which the treatment was administered to the Ss by groups).

Testing.--The Ss of each group received the same two-item test of conservation of number immediately preceding the experimental treatments and on each of the three posttests. These items were administered as follows:

> The E laid out a row of black chips spaced about one chip-width apart. The Ss were given eight red chips, and instructed as follows: "This is a row of black chips. Can you make a row of red chips right beside it so that you have one red chip for each black chip?" The Ss were assisted as necessary. The two extra red chips were removed with the explanation that they would not be needed, and so would be put away. Then E asked, "Now, do we have just the same number of red chips and black

chips?" Upon obtaining agreement, the E said, "Now watch what I do to the black chips." The black chips were bunched into a small, circular group. The E then asked, "Now, are there more black chips, the same number of black and red chips, or more red chips?" The Ss received a score of one if they said "same," indicating conservation, and a score of zero otherwise. At this point, the set of black chips was arranged into a row alongside the red row, but about fifty per cent longer. The E then said, "Now, let's pretend. Let's pretend that these (pointing to the black row) are pieces of chocolate candy wrapped in black paper, and that these (pointing to the red row) are pieces of chocolate candy wrapped in red paper. If you took all the red ones and I took all the black ones, would you have more pieces of candy than me, the same number of pieces as me, or less pieces of candy than me?" Again, the Ss received a score of one if they said "same," and a score of zero otherwise.

Procedures--The first experimental group (Group 1: Set Effect) received a treatment designed to produce a set to say "same" following each of a series of "noncritical" transformations (i. e., transformations leading to no deformation of either row relative to the other). The series of noncritical transformations was followed by a single "critical" transformation, leading to the deformation of one row relative to the other. Figure 1 shows the total series of transformations in the order of actual presentation. The procedure was

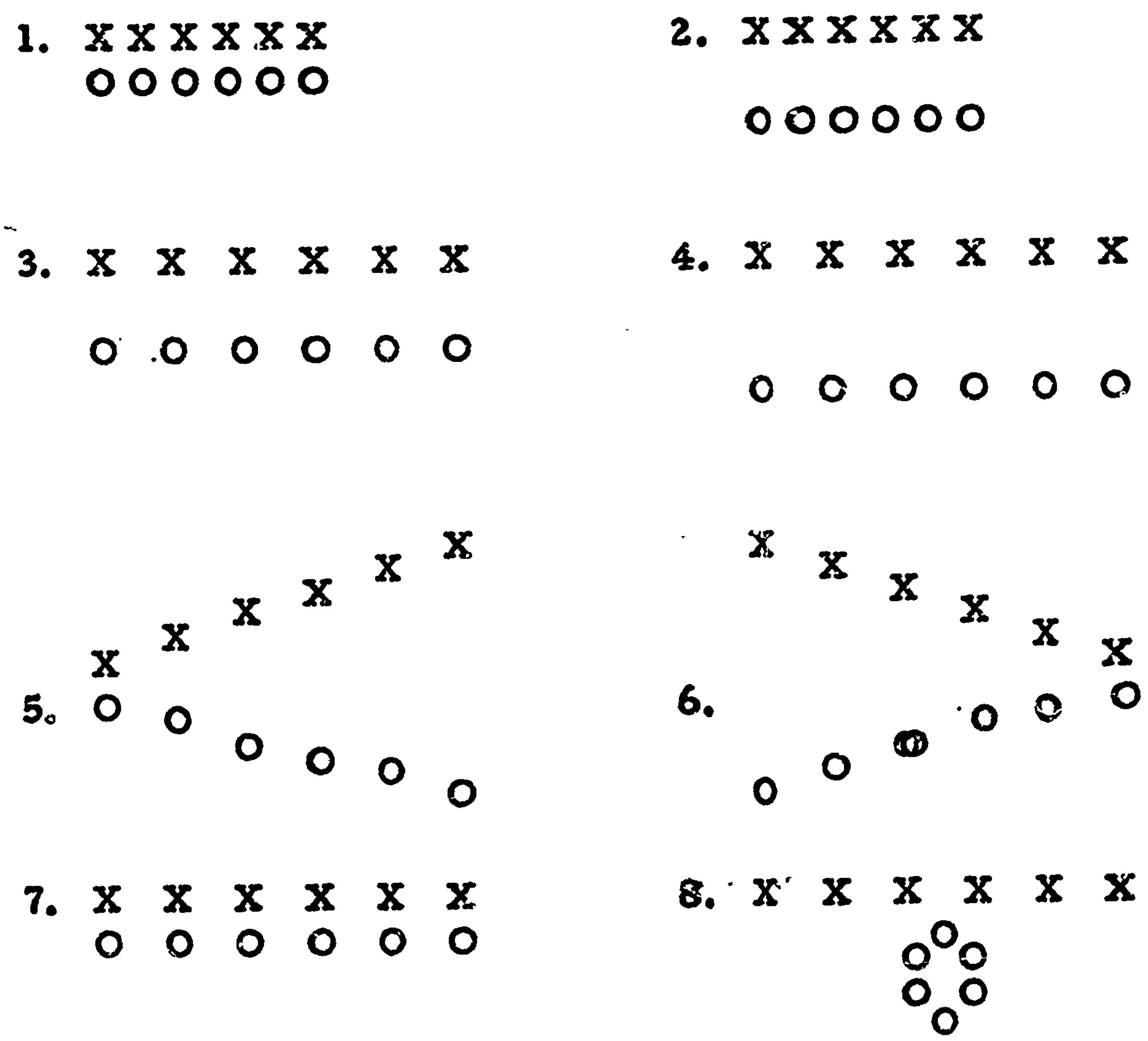

Figure 1.--The Transformations Performed under the Set Effect.

such that "same" responses were elicited with progressively increasing rapidity over the series of noncritical transformations. This was accomplished by progressively decreasing both the period between transformations and the length of the questions asked, as follows:

> With the checkers arranged in the first position shown in Figure 1, the Ss were asked, "Are there more red chips, the same number of red and black chips, or more black chips? For position number 2, they were asked the very same question. For position 3, they were asked, "Are there more red, the same, or more black?" For positions 4 through 8, the question was simply, "more red, the same, or more black?" A record was kept of Ss who failed to say "same" consistently over the series of noncritical transformations. Also, responses following the final, critical transformation were recorded.

The second experimental treatment (Group II: Surprise Effect) consisted of expressing surprise at the responses of conservers of number. The procedure for this group was as follows:

> If the S had been scored as nonconserver on the first item of the pretest, the E said. "Now, remember that when we first started we had a

row of black chips like this (laying out a row of black chips) and a row of red chips like this (laying out a row of red chips). You told me there was the same number of red and black chips, didn't you? Then when we did this to the black chips (bunching up the black chips), you said there were more (red, black) ones. I was very surprised when you said there were more (red, black) ones." If the S had been a nonconserver on item two of the pretest, the E said, "When we were pretending that the chips were candy, we had one row made of black pieces of candy, like this (laying out a row of black chips) and another row made of red pieces of candy right beside it, like this (laying out a shorter row of red chips). You told me there were more (red, black) ones, didn't you? I was very surprised when you said there were more (red, black) ones."

The Ss received one, the other, or both of these surprise treatments, depending on whether they were initially nonconservers on one, the other, or both items of the pretest. Immediately following the Surprise Treatment, all Ss were posttested with the same two-item test used for pretesting.

The third experimental treatment (Group III: Peer Effect) was administered separately to two subgroups, each drawn from one of the two schools involved, and containing nearly equal numbers of conservers and nonconservers. Immediately following individual pretesting, the Ss were assembled in a semi-circular arrangement, so that each S could clearly observe the experimental procedure. Each S was provided with a pencil and with a three- by five-inch card containing two small circles, one red and one blue. The Peer-Effect treatment was as follows:

> The Ss were told, "We are going to play a game with these chips. The game is something like the one you played earlier today, except that we must follow some new rules. Here are the rules. When I ask a question and tell you to answer out loud, I want all of you to say your answer out loud. When I ask a question and tell you to write your answers, I want you to write your answers on the little cards we have given you. You must be careful not to say your answers out loud when I have told you to write them. That is part of the game. Okay? I will show you how to write your answers when the time comes. First, I'll make a row of black chips, like this." (Construct a row of six black chips). "Now, I'll put

one red chip right beside each black chip, so there will be the same number of red chips and black chips." (Construct a row of red chips). "Now, I'm going to ask a question, and I want you to say your answer out loud. Are there more red chips, the same number of red and black chips, or more black chips? What is your answer?" The next step in the procedure was to make a noncritical transformation, leaving neither row deformed, as in the procedure for the Set Effect. The Ss were then asked, "Now, out loud again, are there more red chips, the same number of red and black chips, or more black chips?" A critical transformation, which consisted of bunching up the black chips, followed, after which the E said, "This time, I want you to answer by writing your answer. Be sure that you do not answer out loud. There are two circles on the cards you are holding. Everyone find the red circle and the blue circle. Now, if you think there are more red chips, mark an 'x' like this (demonstrating on the chalk board) inside the red circle. If you think there are the same number of red and black chips. mark and 'x' in the blue circle. Be sure to make your marks without looking to see what anyone else is doing.

Make just one 'x'. Put it in the red circle if you think there are more red chips, or put it in the blue circle if you think there are the same number of black and red chips." After the Ss had marked the circle of their choice, they were instructed to hold up their cards and compare marks. It was pointed out to them that some chose "more," and others "same." However, no adult present either affirmed or disaffirmed any S's choice. The Ss were allowed to interact freely for about two minutes after they had revealed their choices, but none of the adults present observed any discussion on their part of the bases for their choices. Immediately following the treatment session, the children were returned to their usual classes, then conservers and nonconservers alike were drawn individually, at random, from their classrooms for posttesting.

Results

The first results to be presented will be an analysis of variance of gain scores between pretest and first posttest. For the present analysis, the Ss were scored "zero" if they passed neither item on the test of conservation of number, "one" if they passed one or the other item, and "two" if they passed both. Gain scores were derived by subtracting each S's pretest score from his score on the first posttest. The analysis of variance, even though the assumption of interval-level measurement could not be met, was used for the present analysis, and for this analysis only. This analysis made possible a comparison of the mean gains due to the three experimental treatments, of the relative gain between boys and girls, and of interaction, which if significant, would indicate a differential degree of gain between boys and girls across the three treatments.

Table 2 presents the mean gains by sex and treatment groups.[1] The means for the control group are shown in this table, but do not enter in the analysis of variance to follow. Table 3 presents the results of the analysis of variance. We may conclude that there is no significant difference in mean gain between the three treatments.

[1] Initially, twenty-five Ss were assigned to each of the eight (four groups by two sexes) cells. Attrition due to absences or moving left only twenty-two subjects in two of these cells. For convenience, Ss were randomly discarded from the remaining cells, in order to obtain equal cell frequencies.

Table 2

Mean Gains by Sex and Treatment Groups[a]

	Group I Set Effect	Group II Surprise Effect	Group III Peer Effect	Group IV Control
Boys	0.50	0.55	0.45	0.18
Girls	-0.09	0.09	0.27	0.00

[a]N = 22 in each cell.

Table 3

Analysis of Variance: Treatments by Sex

Source	DF	Mean Square	F
Treatments	2	0.296	NS
Sex	1	5.538	12.6**
Interaction	2	0.531	NS
Within	126	0.44	

**Significant at $p < .01$.

Neither is there a significant interaction. However, the mean gain for boys is significantly greater than for girls.

The preceding analysis does not indicate whether treatment gains are significantly greater than those for the control group. To compare the relative gains between each treatment group and the control group, a series of Mann-Whitney U tests were run. A correction for ties was applied to all these tests. It should be noted that since not all these comparisons are independent, the over-all level of significance, taking all comparisons jointly, must be considered to be somewhat lower than the .05 critical region selected for individual comparisons. Scores for these tests were derived in the same manner as for the analysis of variance above.

For the comparison of Group I (Set Effect) with controls, where the results for boys and girls are combined, the Mann-Whitney U test yields $Z = 1.13$, which is not significant at the .05 level. However, since the previous analysis of variance indicated a significantly greater gain for boys than girls, and since in the immediately preceding analysis girls contributed negatively under the Set Effect (i.e., their posttest mean was lower than their pretest mean), it seems reasonable to compare Group I boys with boys in the control group separately. For this comparison, a Mann-Whitney U test yields $Z = 1.79$; $p < .05$. Boys under the Set Effect thus showed significantly greater gain than those in the control group. Due to the _a posteriori_ nature of this comparison, it should be cross-validated by further research.

A Mann-Whitney U test comparing the Surprise Effect with controls, for boys and girls combined, yields $Z = 1.94$; $p < .05$. The group receiving the Surprise Effect made significantly greater gain than controls.

Again using the Mann-Whitney U test, comparing the Peer Effect with controls, and combining boys and girls, Z is equal to 2.24; $p < .02$.

The gain due to the Peer Effect is significantly greater than that for controls.

All three experimental treatments were designed as attempts to produce cognitive conflicts which, if constructively resolved, would give rise to the concept of conservation of number. The experimental procedure associated with the Set Effect made possible a quite direct evaluation of the effectiveness with which the set, and hence the cogni-give conflict, was produced. During the attempts to produce the set, a record was kept indicating which Ss consistently responded "same" when noncritical transformations were made, and which alternated between "same" and either "more" or "less" on such transformations. It was held that if a child did not understand that the number of checkers remained constant in the two rows when their relative arrangement remained the same, he would almost certainly fail to show conservation on critical trials, where their relative arrangement was changed. It was predicted that those who failed to demonstrate an understanding of the terms "more," "same," and "less," in that they failed to develop a set to say "same," would experience no cognitive conflict, and so would remain nonconservers of number. Table 4 shows the relative extent to which gain from the pretest to the first posttest occurred between Ss in whom the set presumably was produced and those in whom it clearly was not. Only one S among the eleven in whom the set was not produced showed a gain. The exact one-tailed probability of this

Table 4

Effect on Gain of Inducement
and Non-Inducement of the Set Effect

	Did Not Gain	Gained
Set Induced	5	11
Set Not Induced	10	1

ten-to-one split under the binomial expansion (P = .50) is .006. On the other hand, eleven of the sixteen in whom the set presumably was produced showed a gain. Clearly, where the set was not produced, there was a marked failure to gain.

It was predicted that the ability to detect the contradiction involved in jointly asserting "more" and "same" is prerequisite to the attainment of any of the conservation concepts. To test this prediction, a separate test of the ability to detect this contradiction was given to all the children in the present experiment. This test was given following the third posttest. The results of this test were used in an attempt to "predict" whether the child gained or failed to gain due to the experimental treatment to which he had been exposed two months previously. Following is the test procedure. Each S was presented two equivalent rows of six black and six red chips, in corresponding positions. After the Ss had agreed that there were the same number of red and black chips, and without any deformation of either row, they were asked, "If two rows have just the same number of chips, does that mean that maybe one row has more chips than the other one? Yes, or no?" Those who responded affirmatively were interpreted as having failed to integrate the concepts 'more' and 'same.' They apparently failed to understand, in their own terms, that the assertion of "more" strictly implies the negation of "same." Subjects who were conservers on both items of the first pretest were excluded from the present analysis, leaving only those who were "free to gain" due to the experimental treatments. For all three treatment groups combined, seventy Ss were free to gain. Twenty-two of these failed on the test of 'more' and 'same.' Of the twenty-two, sixteen failed to gain, and only six gained. The exact one-tailed probability of this sixteen-to-six split is .026. Of the fifty-eight who passed the 'same'-'more' test, twenty-five failed to gain, and thirty-three gained. Clearly, those who failed to integrate the concepts 'same' and 'more' showed a marked failure to gain due to experimental treatments.

Second and third posttests of conservation of number were administered two weeks and two months, respectively, after the training sessions. The results which follow are concerned with the stability of experimentally produced gains, as indicated by performance on these posttests. As in the previous analyses, the scores involved here were derived from the two items of the conservation test given at pretest and again at each posttest. Each S received a combined score for the two items of zero, one, or two. The increases and decreases shown in the tables below represent the frequencies of gains and losses from pretest to each of the posttests, and do not take into account the magnitude of the gains or losses. Table 5 shows the number of increases and the number of decreases from the pretest to

Table 5

Increases and Decreases in Conservation of Number between Pretest and First Posttest[a]

	Group I Set Effect		Group II Surprise Effect		Group III Peer Effect		Group IV Control	
	B	G	B	G	B	G	B	G
Increases	11	2	6	3	8	6	3	1
Decreases	2	3	0	1	0	2	1	1

[a]Each column shows the relative frequency of increases and decreases for twenty-two Ss.

the first posttest, immediately following training. These outcomes are shown only to indicate the frequencies of gains and losses following treatments. No significance tests will be reported on these data, since Mann-Whitney U tests, taking into account not only gains and losses, but also the relative magnitudes of each, have been reported above.

Table 6 shows the frequency of increases and decreases from the first posttest, immediately following treatments, to the second

Table 6

Increases and Decreases in Conservation of Number between First Posttest and Second Posttest[a]

	Group I Set Effect		Group II Surprise Effect		Group III Peer Effect		Group IV Control	
	B	G	B	G	B	G	B	G
Increases	3	4	0	4	2	0	4	3
Decreases	3	0	2	0	0	2	0	2

[a]Each column shows the relative number of increases and decreases for twenty-two Ss over a two-week period.

posttest, two weeks later. Some increase and decrease is normally expected due to possible unreliability. The number of decreases shown in this table is of sufficiently small magnitude, relative to the number of increases due to treatment as shown in the previous table, to warrant the conclusion that gains due to treatments are lasting over a two-week period.

Table 7 similarly shows the increases and decreases from the first posttest to the third posttest, two months following threatments. Again, the number of decreases is too small to suggest any marked loss of previous gains due to treatments.

One further result, shown in Table 8, is relevant in evaluating the stability of gains. The "Increase/Decrease" row shows the number of Ss who showed an increase from pretest to first posttest and also a

Table 7

Increases and Decreases in Conservation of Number between First and Third Posttests[a]

	Group I Set Effect		Group II Surprise Effect		Group III Peer Effect		Group IV Control	
	B	G	B	G	B	G	B	G
Increases	2	3	0	4	2	1	4	4
Decreases	2	0	1	0	1	3	0	0

[a]Each column shows the relative number of increases and decreases for twenty-two Ss over a two-month period.

Table 8

Decreases From First to Third Posttests for all Subjects, and for Subjects Who Had Previously Gained Due to Experimental Treatments

	Group I Set Effect		Group II Surprise Effect		Group III Peer Effect	
	B	G	B	G	B	G
Increase/Decrease	2	0	0	0	1	3
Total Decrease	2	0	1	0	1	3

decrease from first posttest to third posttest. The "Total Decrease" row shows the total number of Ss who showed a loss from the first to the third posttests. Of the total of seven Ss who showed a decrease from the first to the third posttest, it may be seen that six of these were Ss who had previously shown a gain following treatments. The exact one-tailed probability of this six-to-one split under the binomial expansion ($P = .50$) is .062. Thus there is not significantly more loss among those who had previously gained due to treatment than among other Ss. However, due to the small number of Ss involved in the test, this must be considered a tentative conclusion.

PHASE II: THE RESOLUTION OF COGNITIVE CONFLICTS AMONG SELECTED URBAN AND RURAL CHILDREN

Problem

The second phase of the present study is largely exploratory. It is principally concerned with the identification of various non-constructive forms of conflict resolution among children, and with a comparison of such forms among two groups of children that differ in certain social and intellectual background characteristics.

A state of uncertainty, or conflict, is held to be an aversive state capable of prompting inquiry and cognitive reorganization. Moreover, it is held that inquiry and cognitive reorganization will terminate either when the individual evaluates his efforts as adequate, or when he feels he has exhausted his intellectual resources. Presumably, the individual's criteria for evaluating the adequacy of his explanations are acquired largely through a process of social transmission, although other factors, intellectual, developmental, and the like, are no doubt involved also. If the child's parents, peers, or even his teachers accept or typically offer inadequate explanations, then it seems likely that he will adopt corresponding standards of adequacy. On the other hand, if he is more characteristically confronted with higher standards of adequacy, through the corrective influence of others, then presumably he will interiorize these higher standards. The criteria, or standards, of adequacy held by an individual are taken here to be determinants of the extent to which he will carry inquiry and cognitive reorganization. Hence, they are held to bear on the cognitive progress which will result from the individual's day-to-day encounters with events which give rise to perplexities, conflicts, confusions, and doubts.

Each of two groups of first-grade children, one a selected urban and the other a rural group, will be presented with two events designed to produce cognitive conflicts. These two events differ considerably in difficulty, so that one is much more likely than the other to be resolved constructively. The less difficult task, accordingly, will make possible a comparison of the more constructive forms of conflict resolution between the two groups, while the more difficult task will provide more information concerning nonconstructive forms of resolution. The general hypothesis to be tested is that the forms of conflict resolution in the selected urban group will be more constructive than those in the rural group.

Methods

Sample--The selected urban group consisted of the total first-grade enrollment of a demonstration school located in an urban community. There were forty-seven Ss in this group, all of whom had attended kindergarten previously. Eighty-two percent of the fathers of these children had completed some schooling beyond high school. Forty-seven percent held Doctorates. Average age of the Ss was 6-6. It must be emphasized that this is a selected, and by no means a typical, group of urban children. The purpose of the selection was to provide for the clear identification of differences in the forms of conflict resolution occurring among chilren. The rural group consisted of the combined first-grade enrollments of tw rural schools, serving predominantly lower-class families. There were forty-four Ss in this group. Only eight of the fathers of these Ss had completed high school, and only four had any college training. The average age was 6-5.

Procedures--The following procedures were followed with each S individually:

> Two identical bowls were presented, one containing salt water, and the other an equal amount of plain water. The Ss were not informed of any differences between the media, and none was apparent. Two egg-shaped objects made of a silicone substance which floats in salt water but sinks in plain were used. One contained about twice as much substance s the other. The Ss were asked to pretend that these objects were

eggs. The large object was dropped into the plain water, and the small one into the salt water. It was pointed out that one object sank, or went down, while the other one floated, or stayed up. The Ss were asked, "Why did this egg (pointing to larger object) go down and that one (pointing to smaller object) stay up?" The explanations were recorded verbatim. At this point, the E removed the two objects, held them suspended over opposite containers, and said, "Now, I'm going to take this egg and drop it into that bowl, and I'm going to take that egg and drop it into this bowl. Point to the egg that you think will sink, or go down. Point to the egg that you think will float, or stay up." The objects were dropped as indicated. The Ss were asked, "What happened? The first time, this egg (pointing to the larger object) went down, but this time it stayed up. Why did that happen?" Again the explanations were recorded verbatim. The eggs were temporarily set aside, while the contents of the two containers were poured into a larger container and stirred. The Ss were told, "I'm pouring all of this (pointing to one bowl) and all of this (pointing to the other) into one big bowl.

What dc you think the eggs will do if I drop them into this one big bowl?" The predictions were recorded. The second conflict-arousing event entailed the use of an ordinary, partially filled water tumbler and a plastic disc somewhat greater in diameter than the mouth of the tumbler. The disc was placed over the mouth of the tumbler, which was then inverted. The Ss were asked, "What will happen if I hold the glass just this high, and take my bottom hand away? What will the water do?" The hand holding the disc was removed, and the Ss observed that the water remained in the tumbler. They were asked, "Why did that happen?" Their responses were recorded verbatim.

Results

Immediately after the two "eggs" were dropped into the bowls for the first time, the Ss were asked to explain why one "stayed up" and the other "went down." Only one S, from the selected urban group, mentioned any difference between the media. All the rest appealed to differences in the sizes, the weights, or (very rarely) the amounts of air in the two objects. Following the reversal of the objects, the Ss were again asked to explain why one floated and one sank. Their responses were scored as follows: Highly Constructive (HC), if they appealed to any difference in kinds of media; Constructive (C), if they appealed to any difference in the amounts of water;[2] and non-constructive (NC), if they completely failed to recognize that some difference between the media was necessary to account for the observed effects. Table 9 shows the relative frequency of these responses for the two groups. A test of significance yields Chi-Square equal to 13.9; $p < .001$. The responses of the two groups differ significantly, with the selected urban group tending to resolve the conflict more constructively.

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[2] Obviously, the notion that differences in the amounts of water bear on floating and sinking is not accurate. Nevertheless, this is more constructive than an explanation which persistently centers on object differences and ignores other possible variables. This position is consistent with the view that complex concepts are often attained gradually, by successive equilibrations.

Table 9

Constructiveness of Response for Selected Urban and Rural Children

	Highly Constructive	Constructive	Non-Constructive
Selected Urban	10	30	7
Rural	3	19	22

As a routine procedure, with no clear theoretical basis, the performances of boys and girls on this task were compared. The NC, C, and HC responses were treated as ordinal data, and a Mann-Whitney U test, corrected for ties, was run. The initial groups were combined, so that the comparison involves a total of ninety-one Ss, thirty-three of them girls, and fifty-eight of them boys. The Mann-Whitney U test yielded a value of Z equal to 2.64; $p < .005$. The boys resolved the conflict significantly more constructively than the girls. Table 10 shows a classification of the types of nonconstructive responses. Most frequent among these was nonconservation, which is classified here as a fabricated effect. Eleven Ss in all, three from the selected urban group and eight from the rural group, said the amounts, sizes, or weights of the objects had changed after they reversed (e. g., "Now the other egg is heavier"). This is counted as a fabricated effect, in that even casual observation reveals it to have been nonpresent. (Recall that one object obviously

Table 10

Categories of Nonconstructive Responses to the Floating-Sinking Task

	Selected Urban	Rural
Pseudo-explanation	1	6
Fabricated effects	3	8
Pleas of Ignorance	1	5
Other	2	3

contained about twice as much substance as the other, and that on the first occasion this object sank, while on the next it floated.) Next most frequent were pseudo-explanations (e.g., "You switched them around"). Pseudo-explanations are appeals to necessary, but insufficient, and only trivially relevant, conditions. This category was followed in frequency by pleas of ignorance, or simply "I don't know" responses. Only two Ss gave accounts which were outright inconsistent with the effects observed, both holding that something was inside the same one of the two objects before as well as after the reversal. Also, only two gave what appear to be animistic appeals. One said, "The water brought one piece back up"; the other, "The water makes one piece stay up."

After the Ss had given their first explanations, they were asked to observe while the objects were removed, reversed, and held suspended above opposite containers. Then they were asked to predict what would happen if the objects were placed into the containers. Their predictions were scored as either consistent or not consistent with their previous explanations. E. g., if the S had previously said one piece sank because it was heavier, he was scored "consistent" if he now held that the same piece would sink, and "inconsistent" otherwise. It was predicted that the Ss of the selected urban group would give a significantly greater proportion of consistent predictions. Table 11 shows the results of this comparison. Contrary to the predicted outcome, a greater proportion of consistent predictions was obtained in the rural group.

Table 11

The Consistency of Children's Predictions on the Floating-Sinking Task

	Selected Urban	Rural
Consistent	27	35
Inconsistent	20	9

After the Ss had given their explanations of the reversal effect, the contents of both bowls were poured into a large container, and stirred. The Ss were asked to predict what would happen if the objects were now placed into this container. This procedure was such that it would be impossible for the Ss to know definitely what the outcome would be. Consequently, disjunctive predictions, indicating, for example, that either the objects would sink or they would float, were considered to be more constructive than definite predictions. It was predicted that the selected urban group would give a relatively greater frequency of disjunctive predictions than the rural group. Table 12 shows the results relevant to this prediction. A test of significance yields Chi-square equal to 3.01, which is not significant at the .05 level. The hypothesis that the selected urban group will show a greater frequency of disjunctive predictions is not confirmed.

Table 12

Frequency of Disjunctive and Definite Predictions on the Floating-Sinking Task

	Selected Urban	Rural
Disjunctive Predictions	9	3
Definite Predictions	38	41

A second conflict event, considered too difficult for any of the Ss to explain constructively, was presented. The purpose was to elicit a great number of nonconstructive responses, so that categories of such responses could be more clearly established, and any differences between the two groups observed. This conflict event consisted of invertin a partially-filled tumbler of water which had a thin plastic disc placed over the opening. The children were asked first to predict what would happen when the E's hand, which was holding the disc firmly over the opening, was removed. Only one S from the selected urban group and three from the rural group predicted that the water would remain in the tumbler. After the hand which was holding the disc was removed, the Ss were asked to explain why the water did not spill out. Table 13 presents the categories into which the responses were placed, along with the relative frequency of their occurrence for the two groups.

Table 13

Categories of Constructive and Nonconstructive Responses on the Inverted-Tumbler Task

	Selected Urban	Rural
Constructive explanation	2	0
Pseudo-explanation	14	21
Quasi-scientific account	17	12
Fabricated effects	5	4
Pleas of Ignorance	5	3
Unclassified	4	4

Pseudo-explanations and quasi-scientific accounts were the two most frequently occurring categories of response, with the selected urban group giving somewhat more of the latter, and the rural group giving somewhat more of the former. Again, pseudo-explanations state conditions which are necessary, but not sufficient, and which are only trivially relevant in accounting for the observed effects (e.g., "Because the lid is there," or "because the lid stayed on"). Quasi-scientific accounts consist of appeals to scientific or to "scientific sounding" principles which either are irrelevant or have a remote relevance which is clearly not understood by the subjects (e.g., water suction, gravity, wet things stick). Fabricated effects consist of responses which propose devices that are not present, and that even casual observation clearly reveals to be nonpresent (e.g., glue, tape, a little magnet, or a mechanical attachment between the plastic disc and the tumbler). Pleas of ignorance are simply "I don't know" responses. Two Ss from the selected urban group gave responses which were categorized as constructive. Both said that because no air could get into the glass, the lid could not come off. This response clearly reveals the concept of conservation of the total, or joint, quantities contained in an enclosed space: that for a quantity of water to be removed, a quantity of air would have to take its place. It also reveals the ability to deal in proportions.

Additional Findings--As a part of a separate exploratory study, ran concurrently with the present one, each prediction and each explanation the Ss gave was followed by a question designed to measure how certain they were that their answers were right. For this purpose they were pretrained to respond both to a set of verbally-presented response alternatives, and to a corresponding set of graphically-presented response alternatives, in the form of simply-drawn faces. The verbal alternatives and their graphic counterparts, respectively, were: "I am very sure my answer is right" (smiling face); "My answer may be right, but I am not so sure" (slightly smiling face); and "My answer is probably wrong" (slightly unhappy face). The purpose of this procedure was primarily to provide an index of equilibrium-disequilibrium. A state of cognitive conflict is viewed here as a state of disequilibrium. An attempt at conflict resolution, if considered by the individual to be successful, results in a new equilibrium. The position is taken that when the individual feels certain about his explanation, he will be rid of the aversive effect of the conflict, and the inquiry process will terminate. If he is less than certain, then the aversive residue either may prompt further inquiry, or it may be displaced by some nonconstructive means.

On the assumption that the Ss of the present experiment possessed some ability to evaluate their explanations, it was predicted that explanations which were more constructive would be held with greater certainty than those which were less constructive. An examination of the data clearly revealed that this prediction did not hold for the task involving floating and sinking. Thus, nonconserving responses, indicating that the objects had changed in weight, size, or amount, and pseudo-explanations, indicating that the observed events were due to the reversal of the objects, were held with no less certainty than constructive responses.

It was also predicted that, since the inverted-tumbler task was more difficult to explain than the floating-sinking task, certainty would be lower for explanations of the former than for those of the latter. To test this prediction, the number of Ss who showed increases in certainty from the former to the latter task was compared with the number who showed decreases. Decreases in certainty were expected to exceed increases. An examination of the data revealed the outcome to be just the contrary. Only fifteen decreases in certainty were obtained, while twenty-five Ss showed increases. A more detailed examination of the data shows that this outcome is largely due to the high degree of certainty associated with pseudo-explanations, the most frequent category of explanation on the inverted-tumbler task.

It is possible, of course, that the Ss were unable to evaluate their subjective certainties, and that consequently no confidence can be placed in the certainty measure. To evaluate the construct validity of the measure of certainty, it was applied in additional situations, where clear directional predictions of certainty could be made. For instance, one hundred and eleven first-grade children were given a two-item test of conservation of number. It was predicted that consistent conservers would be more certain of their conclusions than either consistent nonconservers or transitionals (those who alternated between conservation and nonconservation over the two items of the test). It was also predicted that nonconservers would be more certain of their conclusions than transitionals. The certainty scores associated with the two items of the conservation test were added together, and the results for the twenty-eight nonconservers, twenty-four transitionals, and thirty-nine conservers were compared. A Kruskal-Wallis one-way analysis of variance yielded H equal to 128; $p < .001$. Individual comparisons between groups were made with Mann-Whitney U tests, corrected for ties. Comparing conservers and nonconservers, this yielded Z equal to 3.112; $p < .001$. Conservers expressed significantly greater certainty than nonconservers. For the comparison of transitionals with conservers, Z was equal to 3.32; $p < .001$. Conservers expressed significantly greater certainty than transitionals. However, nonconservers did not express significantly greater certainty than transitionals.

Two further comparisons were made for the purpose of evaluating the construct validity of the certainty measure. On the task which involved floating and sinking objects, the Ss were asked to explain why one object floated and the other sank upon first being placed in the two containers. Then they were asked to predict which would sink and which would float after the objects had been removed, reversed, and held suspended over opposite containers. These predictions were scored, as discussed earlier, as either consistent or not consistent with the preceding explanations. The explanations and the predictions were both followed by tests of certainty. It was predicted that lower certainty scores on the explanations would be associated with less consistent predictions, and higher certainty with more consistent predictions. A Chi-Square test, crossing the two levels of consistency with the three levels of certainty, yielded Chi-Square equal to 7.7; $p < .05$. There was a significant tendency for less certain explanations to be associated with less consistent predictions.

Finally, it was held that on the inverted-tumbler task, the members of the selected urban group would be better capable of evaluating the correctness or incorrectness of their explanations than those of the rural group. And since practically none of the children of either group were able to resolve the conflict associated with this task constructively, it was predicted that subjective evaluations of certainty would be lower for the selected urban than for the rural group. Table 14 shows the frequency with which each level of certainty was expressed in the two groups. An analysis of these results yields Chi-Square equal to 8.22; $p < .025$. Subjective certainty was significantly lower for the selected urban than for the rural group, as predicted.

Table 14

Subjective Certainty Expressed by Children When Confronted with a Conflict too Difficult to be Resolved Constructively

	Certainty		
	1 (Low)	2	3 (High)
Selected Urban	7	20	20
Rural	6	8	30

GENERAL SUMMARY AND CONCLUSIONS

A major finding of this study is that various means may be employed for producing cognitive conflicts among children in order to accelerate their cognitive progress. In the first phase of the study, three conflict-producing procedures were employed, each designed to prompt first-grade children to attain the concept of conservation of number. The first of these was the Set Effect. It consisted of an attempt to elicit two incompatible conclusions simultaneously. First, an attempt was made to establish in the children a set to say "same" by repeatedly calling for a comparison of the number of objects contained in two rows as they underwent equivalent transformations. Then the objects in one row were deformed, prompting nonconservers to conclude that it contained "more" or "less." This procedure resulted in significant improvement for boys; however, the girls actually showed a slight decrease in conservation from pretest to posttest.

The two other conflict-producing procedures both consisted of exposing nonconservers of number to the corrective influence of others. In one of the treatments the investigator gave a verbal expression of surprise when a conclusion indicating nonconservation was given by a child. In the other, nonconservers were exposed to the contradictory conclusions of their peers who were already conservers. The gains due to each of these treatments were significantly greater than those achieved by the controls. Moreover, posttests administered two weeks, and again two months after the treatments indicated that the experimentally-produced gains were lasting.

An additional finding was that under the Set Effect many children failed to conserve number even when the objects in both rows were transformed simultaneously, with no deformation of either row relative to the other. These children obviously failed to develop the set to say "same." And since the development of this set was held to be necessary for prompting the attainment of conservation, it was predicted that they would show significant failure to gain. This prediction was borne out by the results. In order to explore this effect further, a separate test was given to the subjects of all three experimental groups. This test was designed to indicate whether the children understood that "more" and "same" are mutually exclusive relations--i.e., that the assertion of one implies the negation of the other. Failure to integrate these concepts was associated with a significant failure to gain due to the experimental treatments. A rather obvious implication for instruction is that conflict-producing events will not be effective unless the subjects possess the prerequisites for experiencing the intended conflicts.

This investigation was undertaken, not primarily as an attempt to train children in conservation of number, but to explore the instructional implications of Piaget's position on equilibration. One purpose has been to test the general hypothesis that the misconceptions of children may be displaced by providing evidence which, when coupled with these misconceptions, gives rise to cognitive conflicts. The results, in general, confirm this hypothesis. A second purpose has been to explore various means by which cognitive conflicts may be produced. In this regard, the emphasis has been on the development of techniques readily adaptable to the instructional situation. Feigned surprise is one such technique. It encourages children to rethink a faulty position taken. No doubt, it is a technique which already appears in the repertory of instructional devices employed by many teachers. Its most effective use would require considerable knowledge of the misconceptions children typically hold, and the careful manipulation of conditions for eliciting them. In this regard, it is an approach reminiscent of the Socratic method. Once a mistaken conclusion has been expressed, it may require no more than an expression of surprise to cause the individual to reexamine his assumptions and discover their untenability.

There is also little question that in the normal course of interaction in the classroom, the contradictory conclusions of peers often come into contact, prompting a reconciliation of views, and cognitive progress on the part of those whose views were in error. This too is an effect which may be employed most fruitfully when the conditions for its occurrence are carefully designed and controlled. Further research and development are needed in order to explore the content areas and the conditions under which it may be most effective.

One of the more striking outcomes of the present study was the extent to which boys outperformed girls in resolving cognitive conflicts constructively. Over all three treatment groups of the first phase, and in the floating-sinking task of the second phase, boys performed significantly higher than girls. With respect to the first phase, the possibility that this outcome could have been an artifact of statistical regression was considered. If, in spite of randomization, girls were higher and boys lower on conservation of number at the outset, the girls could have regressed negatively toward the mean, and the boys positively, on posttests. However, there was no significant difference between sexes on the pretest of conservation of number, even though the sample size involved in the comparison was large (nearly two hundred). If one concludes that boys tend to be higher than girls in whatever abilities are necessary to attain conservation, and that this accounts for their superior performance, then another question arises: Why did they not, then, show significantly higher performance than girls on pretests? One hypothesis suggested by these outcomes is that the prerequisites involved in the "normal" acquisition of conservation are not the same as those involved in its attainment through the resolution of experimentally-produced cognitive conflicts. However, it is in no way clear to the present writer what the nature of any such differences could be.

The second phase of the present study was largely exploratory. Its focus was on the identification of nonconstructive forms of conflict resolution among children, following the position that once these have been identified, it may be possible to train children to avoid them. A second basic objective has been to evaluate the relative need for such training among children who differ in certain social and intellectual background characteristics. A main limitation of this phase is that while the selected urban and the rural children differed on numerous antecedent variables, the design of the study did not make it possible either to isolate or to control any of these in order to discover which were determinants of the obtained differences. The investigation was undertaken with full knowledge of this limitation, however, and did yield information consistent with its three specific purposes. The first of these was to prompt children to discard a more obvious, but irrelevant variable in a situation, and to consider other possible variables which were not so obvious. In the floating-sinking task, nearly all the subjects first suggested that object differences, which were obviously present, accounted for the observed floating and sinking effects. However, when contradictory evidence was presented, most of them discarded this variable in favor of less obvious variables associated with the media. It is worth noting that those who failed to do so tended to give explanations which, though inaccurate, were nevertheless consistent with the observed effects. For instance, many held that the amounts, sizes, or weights of the objects changed when they were reversed. If this had happened, and had operated as the subjects apparently supposed, it would have accounted for all the effects observed. A limitation of this portion of the investigation is that there is no way to know how many of the subjects may have discovered for the first time that differences between media bear upon floating and sinking, and how many may have had this concept prior to their encounter with the floating-sinking task. However, in that the most frequently mentioned property of the media was the amount of water, and in that this property is not actually relevant to floating and sinking, it seems reasonable to rule out specific previous instruction for most of the subjects involved.

The second purpose of this phase of the study was to identify nonconstructive modes of conflict resolution. It was held that inquiry and cognitive reorganization would terminate whenever an individual evaluated his own efforts at conflict resolution as adequate, or when he felt he had exhausted his intellectual resources. Notably few among the children's responses were appeals to animism and artificialism. This may have been in part due to the nature of the tasks, and in part due to the nature of the culture. Other tasks may have elicited a greater number of such appeals on the part of the present sample of subjects, or the same tasks may have elicited a greater number in another culture.

Among the subjects of this study, the most frequent forms of nonconstructive conflict resolution employed were pseudo-explanations, quasi-scientific accounts, and fabricated effects. There were also some pleas of ignorance, indicating that the subjects felt they had exhausted their intellectual resources.

The third purpose of this phase of the study was to compare the forms of conflict resolution employed by selected urban and rural children. The general hypothesis tested was that selected urban children will resolve conflicts in thinking more constructively than will rural children. The results failed to provide unqualified support for this hypothesis. In resolving the conflict associated with the floating-sinking task, the members of the selected urban group performed significantly higher than those of the rural group. This was shown by their greater tendency to discard object differences as a relevant variable, and to propose that some difference between the media was involved. In this task, the objects were first placed in the media so that the small one floated and the large one sank. After the subjects had attempted to explain this event, they were asked to predict which object would float and which would sink when they were removed, reversed, and placed into opposite containers. These predictions were scored as either consistent or not consistent with the immediately preceding explanations. It was predicted that a greater frequency of consistent predictions would occur in the selected urban than in the rural group. Contrary to this predicted outcome, consistent predictions were more frequent in the rural group.

Obviously, the original hypothesis must be revised. One possible line of revision proceeds from the possibility that the selected urban children expected a "trick," or at least an outcome associated with less obvious rather than more obvious variables. If so, this would be an instance of the well-known phenomenon of "test wiseness." It may still be that the original hypothesis will hold for younger subjects from similar groups. It may hold, for instance, where younger selected urban children have attained a greater ability to maintain consistency, but not yet an expectancy for less obvious outcomes.

Following the reversal of the two objects, the contents of both containers were mixed together. The subjects were asked to predict what would happen if the objects were placed in this mixture. Since they could not have known what would happen, disjunctive predictions (e.g., "Either they will float or they will sink") were scored as more constructive than definite predictions. The results did not support the prediction that the selected urban children would give a significantly greater frequency of disjunctive predictions. However, since the obtained results were in the predicted direction, and since there were so few disjunctive predictions offered, this hypothesis deserves to be put to test in a situation which provides more variance.

As an addition to the second phase of the study, the children were required to express the certainty with which they felt their answers to be right. The construct validity of the measure of certainty was reasonably well established by demonstrating significant differences in certainty in situations where such differences would clearly be expected on theoretical grounds. For instance, consistent conservers of number expressed greater certainty than either transitionals (those who alternated between conservation and nonconservation) or consistent nonconservers. On the floating-sinking task, nearly all the subjects held that object differences were involved when the objects were first placed into the media. When asked what would happen when the objects were placed in opposite containers, some gave predictions which were consistent with their previous explanation, and some did not. Those who had expressed less certainty with their previous explanations showed a greater tendency to give inconsistent predictions. Even though the certainty measure was thus shown to be reasonably valid, there were two comparisons in which significant differences were expected, but failed to occur. On the task which involved floating and sinking, nonconstructive explanations were held with no less certainty than constructive explanations. Also, certainty was no less for the inverted-tumbler than for the floating-sinking task, even though the conflict associated with the former was considerably more difficult to resolve constructively than that associated with the latter. It was observed that this outcome was largely due to the high certainty expressed by those who gave pseudo-explanations. For instance, on the floating-sinking task, high certainty was expressed by those who held that the observed effects occurred because the objects were "switched around"; and, similarly, on the inverted-tumbler task, high certainty was expressed by those who held that the water stayed in the glass "Because the plastic was there." Theoretically, there remains an aversive residue of uncertainty whenever an individual cannot resolve a conflict to a degree which he considers adequate. The preceding results suggest that when left with such a residue of uncertainty, individuals may seek out certainty, and attain it by appealing to some trivial but incontestable fact. Pseudo-explanations are appeals of this nature. In that they refer to necessary (though trivially relevant) conditions, they may be held to be correct with a high degree of certainty. And so long as the individual is not concerned with their sufficiency, he may consider them adequate, and thus terminate inquiry and cognitive reorganization. This interpretation is consistent with the position of Inhelder and Piaget (8) to the effect that children in the early levels of the concrete operational stage of thinking may often be able to evaluate the necessity of certain conditions in explaining a phenomenon, but are not concerned with evaluating their sufficiency.

There was some evidence to indicate that children from the selected urban group were more concerned with evaluating the adequacy of their explanations than those from the rural group when asked to say how certain they were that their answers were right. On the inverted-tumbler task (but not on the floating-sinking task) practically no children in either group were able to resolve the conflict constructively, since the concepts required for doing so were too advanced. In a sense, then, the adequacy of the explanations given was controlled over the two groups: both gave practically all nonconstructive, or inadequate explanations. It was held that if the members of the selected urban group were more capable of evaluating the adequacy of their explanations, they would express less certainty in this situation. The results showed significantly less certainty in the selected urban than in the rural group. Apparently, when asked how sure they were that their answers were right, those in the selected urban group tended to interpret the question in the broader sense, and those in the rural group in the narrower sense.

Further research is needed in order to determine whether those who express a high degree of certainty in such situations tend to terminate inquiry and cognitive reorganization prematurely. This outcome would be expected if an expression of high certainty indicates that the individual has evaluated his explanation as adequate. Further research is also needed to determine whether individuals can be trained in evaluating the adequacy of their attempted explanations. In the present study, it was assumed that standards of adequacy are socially transmitted, and that those in the selected urban group had interiorized generally higher standards than those in the rural group. It may well be possible to train children to detect various forms of inadequate explanations, with the result that they become more persistent in their attempts to resolve conflicts through inquiry and cognitive reorganization. The benefits, in terms of subsequent cognitive progress, would certainly carry beyond the realms of the classroom situation.

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