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A STUDY OF HOW A CHILD LEARNS CONCEPTS ABOUT CHARACTERISTICS OF LIQUID MATERIALS. FINAL REPORT.

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THE PURPOSE OF THE STUDY WAS TO EXPLORE THE PIAGET CONCEPT OF CONSERVATION WITH REGARD TO THE CHILD'S CONCEPT OF THE PROPERTY OF LIQUIDS. AN INVESTIGATOR-CONSTRUCTED CONSERVATION INVENTORY WAS GIVEN TO 45 KINDERGARTEN AND FIRST GRADE PUPILS SELECTED FROM THE PRAIRIE ELEMENTARY SCHOOLS, URBANA, ILLINOIS, TO PROVIDE AN INDEX OF THE CHILD'S UNDERSTANDING OF CONSERVATION. THIS INVENTORY EMPLOYED TASKS USING SOLID OBJECTS, VERBAL PREDICTION OF LIQUID BEHAVIOR, COMPENSATION PROBLEMS, AND THE MANIPULATION AND PREDICTION OF LIQUID TRANSFER. EACH CHILD WAS GIVEN THE PEABODY PICTURE VOCABULARY TEST (PPVT) IN ORDER TO ESTABLISH MENTAL COMPETENCE AND LEVEL. THIRTY CHILDREN WERE IDENTIFIED AS NONCONSERVERS AS A RESULT OF THE PRETESTS AND DIVIDED INTO 15 PAIRS MATCHED ON MENTAL AGE SCORES AND ON THE PPVT. THE 15 EXPERIMENTAL CHILDREN WERE GIVEN FIVE DAYS OF TRAINING SESSIONS OF 15 TO 20 MINUTES PER DAY FOCUSING ON ESTABLISHING IN THE CHILD THE IDEAS OF (1) CONCEPTUAL INDEPENDENCE, AND (2) COMPENSATION. THE TRAINING WAS DONE IN SMALL GROUP INSTRUCTIONAL SESSIONS WITH THE EMPHASIS ON OBSERVATION BUT NOT ON ACTIVE PARTICIPATION. THE CONSERVATION INVENTORY AND THE PPVT WERE ALSO USED AS A POST-TEST. THE ANALYSIS OF THE DATA INDICATED (1) A SIGNIFICANT IMPROVEMENT ON THE CONSERVATION INVENTORY BY THE EXPERIMENTAL GROUP, AND (2) NO CHANGES ON THE PPVT. THE EDUCATIONAL IMPLICATION IS THAT THOSE PROPERTIES OF LIQUIDS THAT HAVE BEEN ASSUMED TO STAND FOR CONSERVATION CAN BE TAUGHT THROUGH INSTRUCTION. APPENDIXES INCLUDE (1) THE BASIC CONCEPTS TEST, AND (2) SPECIFIC TRAINING TASKS USED. (DS)

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U. S. DEPARTMENT OF
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The concept of conservation has received much attention because of its role in the theoretical position taken by Piaget. According to Piaget (1941, 1960), the child's cognitions developed in a certain invariant order, proceding from the sensori-motor stage of development (during which the child has no lasting cognitive structures and is influenced by the sensory present), to the concrete operations stage (during which the child has progressed to a more distant kind of interaction, one which allows him to store data and handle a wider range of cognitive processes), to the stage of formal operations.

The phenomenon of conservation is theoretically associated with the concrete-operational stage. This phenomenon has been noted by many observers. The child of about 6 - 7 years recognizes the invariance of certain properties of objects or liquids, despite changes in the perceptual environment.

The key question related to conservation is: What is its meaning in terms of cognitive developmental theory? Is it a key phenomenon demonstrating that the child has the ability to multiply relationships (the ability to see that for every change in height in a column of liquid, for instance, there is a compensating change in width) which represents a substantial and important change in the ability of the child to process information that he receives from his environment? Is the conserving child different from the non-conserver in his understanding of reversibility, his schemata of atomism, and his ability to attend to the process of transformation rather than the end states?

Another aspect of the conservation concept is that it is supposed to be developmentally timebound and cannot be induced through mere verbal training. The child is supposed to acquire the concept only through 'equilibration' which suggests that the child would grasp the concept only through the actual manipulation of concrete objects.

The present experiment attempts to test some of the aspects of this interpretation. It attempts to answer the question: Does the conservation response play the theoretical role that it is supposed to play? Does the non-conserving kindergarten child have a knowledge of reversibility? Does he have the schemata of atomism (the knowledge that some matter is made up of non-comprehensible, fixed units of stuff)? Does he have the knowledge of the transformation process demanded by the conservation response? Can his knowledge of conservation be induced through instruction that does not provide the experience with concrete objects and thus does not allow for equilibration?

Normative Studies

There have been many experiments concerned with the emergence of conservation responses. In the initial conservation study, Piaget and Inhelder (1941) reported a sequential order of acquisition--matter, weight, and volume, with conservation of matter emerging at 7-8 years. Replications have been conducted by Elkind (1961), Lovell (1959), Smedlund (1959), Vinh-Bang (1959), and others. Vinh-Bang obtained norms for 1500 Geneva children. His data, like those of Elkind and Lovell, generally support the assertion that conservation emerges in the order suggested by Piaget and Inhelder--amount, weight, volume. Sigel and Mermelstein (1965) reported that the sequence does not hold for rural Negro children. Only the girls in this study exhibited conservation in the substance-weight-volume order. Comparison of six and nine year old boys yieled no significant differences in performance on four conservation tasks.

Conservation-Induction Studies

The question of how a child is transported from preoperational patterns of behavior to concrete operational thought has prompted a number of studies. Piaget provides a rough sketch of transitional process. He stipulates (1960) that the development of mental activity is "...a function of this gradually increasing distance of interaction and hence of the equilibrium between an assimilation of realities further and further removed from the action itself ..." A kind of dynamic equilibrium is suggested between assimilation and accommodation. When a cognitive structure comes into conflict, a state of disequilibrium exists. To establish a new state of equilibrium, the child must internalize a response that produces a new and more remote interaction. The entire process revolves around action.

The stages of equilibrium and disequilibrium that lead to conservation of amount are:

1. The child (out of chance) focuses on one of the two dimensions of the column of liquid--either the height or the width. His actions lead to conflict.

2. The child, in attempting to resolve contradictions, abandons the original focus and attends to the other dimension. His actions lead to conflict.

3. The child, recognizing the failure of strategy two, focuses on both dimensions in turn--first width, then height.

4. Finally, the child considers both height and width simultaneously, using compensation reasoning (although the column of liquid becomes wider when transferred, it becomes "lower," also).

The consensus is that the Piagetian interpretation implies an internalization process which is relatively independent of "external motivators."

Smedslund (1961, P. 13) contrasts external reinforcers with the internalization process by suggesting that the process of equilibrium "is highly influenced by practice which brings out latent contradictions and gaps in mental structure, and thereby initiates a process of inner reorganization." But the fact that practice can stimulate latent contradictions, according to Smedslund, is not to imply that the contradictions can be induced through practice. An explanation based on external reinforcement, he suggests, is not acceptable, because it would necessitate that "...the subjective validity and necessity of the inferences of conservation derive from an empirical law."

Smedslund performed a series of training experiments including one which attempted to test the relative effectiveness of external reinforcement as compared with equilibrium learning. One group of 16 children practiced adding and subtracting materials, checking the weight of the transformations on a scale. The control group (N=16) did not engage in the training sessions, but took the pre- and post-tests. The post-tests were administered--the first a week after the pre-test; the second a month after the first post-test. Although the experimental group showed improvement, the control group did also, with four subjects showing stable conservation on the post-tests. Smedslund suggested that the experimental variables in the experimental training session were neither necessary nor sufficient conditions for the acquisition of conservation. He tentatively concluded that the cognitive conflict induced by the pre-tests alone might be the crucial factor.

In another experiment (1961 b), Smedslund attempted to induce conservation of substance by practice in conflict situation without external reinforcement (although such conditions are theoretically impossible). Based on the performance of four of 13 subjects who showed development of conservation responses, Smedslund concluded that this procedure is more effective than others, and that the experimental results tend to favor the explanation of learning as equilibrium.

In perhaps his most influential experiment (1961 c), Smedslund attempted to demonstrate that conservation of weight learned empirically by "external reinforcement" is a pseudo-concept. He assembled two groups of children, one of which acquired the concept of conservation of weight through external reinforcement, the other of which acquired it through non-experimental exposure. To test the pseudo-concept hypothesis, he subjected the children to extinction trials during which the experimenter surrepitiously removed some clay from the deformed piece so that the child was faced with instances of apparent non-conservation of weight. All of the experimental children relinquished their concept while about half of the others showed resistance to extinction.

Brison (1965) used "shills" to train conservation responses. Two conserving children were present during the training of five nonconserving children. On repeating trials, the experimenter filled identical glasses to different levels with juice and poured juice from the glass containing the most juice to a wider container. He then directed the children to point to the container that had the most juice. Brison hypothesized that the non-conserving children would follow the lead of the conservers, which they did. The experimental children showed improvement, and the conservation response transferred to both clay and sand. On an extinction item (in which liquid was returned to a glass that looked like the original but had a thick bottom) experimental subjects tended to respond in the same way as subjects who previously had acquired the concept of conservation.

Bruner (1964) substituted the terms of <u>enactive</u>, <u>iconic</u>, and <u>representational</u> for the traditional Piagetian labels of developmental stages, and added a note about the importance of language in the transition from the <u>enactive</u> to the <u>iconic</u> stages (which correspond to preoperational and concrete-operational). He suggested that the child's language must be activated to solve problem situations where perceptual cues are not obvious or present.

Frank (reported by Bruner, 1964), using an approach considered consistent with this explanation, divided the total activity that is usually perceived in the liquid-transfer situation into two separate acts-- the act of pouring and the act of receiving. She initially placed the receiving beaker behind a screen and asked the conservation question. She later removed the screen and repeated the transfer without obstruction. Under the split-act condition there was a substantial increase in conserving responses among five and six year old children, but no change was noted among four year olds.

Inhelder, Bovet, Sinclair, and Smock (1966) take issue with Bruner on the kind of training that should be used to induce conservation.

> A major difference in our procedure, as contrasted to that reported by Bruner, is that at no time did our procedures <u>mask those aspects of the situation that tend to create obstacles</u> to the correct solution. Rather, the experimental arrangements and procedures were designed to elicit awareness of the conflict (i.e., between anticipation and outcome, or more profoundly, between perceptual pregnance and operational necessity) and of its source, which is one of the presumed necessary conditions for the transition from a limited form of reasoning to an operational system. (P. 161)

Following this line of reasoning, we would be lead to the conclusion that any teaching would be best conducted when the critical variables are more or less embedded in natural settings. The training procedures developed by Bereiter and Engelmann (1966) for teaching academic skills to young children contradict this assumption and favor the idea that concepts are more readily conveyed when they are isolated and verbalized.

However, Inhelder, Bovet, Sinclair, and Smock draw a distinction between information (which can be conveyed through language) and processes (which are not influenced by language).

> Our general systematic conclusions with respect to the effects of language training are straightforward. First, language training, among other types of training, operates to direct the child's interactions with the environment and thus to "focus" on relative dimensions of task situations. Second, the observed changes in the justifications given for answers in the conservation task suggest that language does aid in the storage retrieval of relevant information. However, our evidence offers little, if any, support for the contention that language learning, per se, contributes to the integration and coordination of "informational units" necessary for the achievement of conservation concepts. (P. 163)

METHOD

Subjects.

The subjects in the present study were drawn from a total of 87 kindergarten and first grade children attending the Prairie elementary school in Urbana, Illinois. All of these children were given an individual administration of the Peabody Picture Vocabulary Test (PPVT). Those children who scored in the mentally retarded range of the test were eliminated from consideration.

From the remaining sample, thirty children were matched by pairs on the basis of Mental Age scores on the PPVT. Fifteen of these children were randomly assigned to the Experimental group for later training and their pair was assigned to the Control sample. Fifteen children had already mastered the principle of conservation (according to the criterion noted below) formed a third group.

Table 1 shows the pairing of Experimental and Control groups by CA and MA. In no instance was there a difference of over four months of MA in the fifteen pairs. The sample, as a whole, was slightly above average in ability for their age, reflecting the middle class character of the school population. The conservers were somewhat older and more mentally advanced than either the Experimental or Control groups.

A Basic Concept test and the Conservation Inventory (devised by the senior author) were administered to each child individually. The total testing time per child was about thirty minutes and the motivation was consistently high. The Basic Concept test (see Appendix A) was designed to test the child's ability to handle concepts that were prerequisites to the ability to conserve. These were:

a. The ability to interpret instructions that required him to make a choice.

b. The child's ability to multiply relations, to produce a compound judgment that A is the same color as B <u>and</u> that A is not the same shape as B.

c. To make a simple judgment involving the concepts of <u>more</u> or <u>less</u>.

The Conservation Inventory was designed to test the generalization of compensation reasoning as it applied to liquids and representations of liquids, as it applied to three-dimensional solids, two-dimensional rectangles, and as the concept is influenced by different perceptions or 'end states'.

Table 1 also indicates the distribution of the present sample regarding their initial assignment as a conserver, partial conserver or a nonconserver. The criteria for this initial judgment was as follows:

a. If he passed the criterion for the Conservation Inventory (first five items correct) and passed all items on the Basic Concept test he was labelled a CONSERVER.

b. If he failed to meet the criterion for the Conservation Inventory but passed all the items on the Basic Concept test he was termed a PARTIAL CONSERVER.

c. If he failed to meet the criterion for the Conservation Inventory and failed any one of the Basic Concept test items, he was labelled a NONCONSERVER.

Table 1

Matching Experimental and Control Subjects on PPVT

EXPERIMENTAL		CONTROL		CONSERVERS	
CA	MA	CA	MA	CA	MA
Partial Conservers					
5-8	5-1	5-3	5-1	7-0	7-6
5-9	5-9	5-8	5-9	6-5	6-10
5-4	5-11	5-10	5-11	6-11	7-6
5-4	6-1	5-5	6-1	7-0	8-9
5-5	6-3	5-10	6-3	6-11	9-2
5-2	7-10	5-5	7-10	7-2	10-10
5-5	7-1	5-9	7-3	6-8	7-3
5-9	6-6	5-10	6-8	6-9	7-3
5-3	6-6	5-4	6-10	6-7	6-10
5-2	5-7	5-11	5-11	6-4	7-3
Non Conservers					
5-2	6-10	6-1	6-10	7-2	7-10
5-9	5-7	6-1	5-5	5-7	6-10
5-5	6-1	5-5	6-1	7-1	10-4
5-4	6-1	5-11	6-10	6-7	8-5
5-3	7-6	6-0	7-10	6-8	8-5

The Conservation Inventory.

The ten items of the inventory (which are summarized in Table 2) are presented in some detail below so that the reader can understand the basic tool used in the present study. The questions on the Inventory were designed so that the child can answer with either a yes-no response or by doing something--pointing or operating the juice strip (in items 4 or 5). The items did not test the child's ability to produce statements such as 'They do not have the same amount.' or to justify responses.

The basic questions were phrased in such a way that the child can attend to the objects under investigation one at a time. Instead of using the phrasing that involves simultaneous examination, "Are they the same?' or 'Do they have the same amount of juice?', the questions in the Inventory are phrased 'Does this glass have just as much water (or juice) as this other glass?' This question form allows for greater clarity of response. The same basic question form is used with six items, 1,2,3,4,8,10.

Items 1 and 2 are presented in connection with two identical glass tumblers and one wide glass tumbler.

1. Fill identical glasses to the same level. Explain, "I want this glass to have just as much water as this other glass. Does this glass have just as much water as this other glass?"

   Transfer the water from B to C (wide glass). "Does this glass have just as much water as this glass?" If not, "Which one has more?"

   Same B more C more

2. Ask, "What would happen if I poured this water back into this glass? Would this glass (B) have just as much water as this glass (A)?" If not, "Which would have more water?"

   Same B more C more

Items 3, 4, and 5 are presented in connection with a model (see Figure 1) that has two cut-out rectangles supposed to represent glasses. The left rectangle is narrow, the right is wide, both are the same height. A movable yellow strip can be lowered or raised in the cut-out area of a glass by operating a handle that extends beneath the model. When the handle is moved, it gives the impression of lowering or raising the juice level in the glass. The "glasses" are calibrated with ten equally spaced marks on the inner face of the cut-out area, where they are not likely to be observed. The marks are read from top to bottom with 0 representing a full glass and 10 an empty glass.

Table 2

Conservation Inventory Items

ITEM	EQUIPMENT	DESIGNED TO TEST
1.	Two identical glasses one wide glass	Confusion of level with amount. Confusion about expandable nature of water.
2	Two identical glasses one wide glass	Reversibility.
3	Model, with only left juice strip present	Confusion of expandable nature of liquid: Confusion between level and amount
4	Model, with subject adjusting right juice strip	Discrepancy between verbal statement in 3
5	Model, with subject adjusting right juice strip	Comparison with verbal comment about amount. Response consistency with 4.
6	Stimulus card: dot patch; test card: two patches having different areas	Consistency with performance in model
7	Stimulus card: rectangle test card: two rectangles, each having different areas	Consistency with performance in handling model
8	Two dowels of same length but different widths	Consistency with performance in handling model and glasses
9	Investigator, pointer, tape mark on wall	Confusion about reversibility. (compared with Item 2)
10	Two dowels of same length but different widths	Consistency with performance in handling the model.

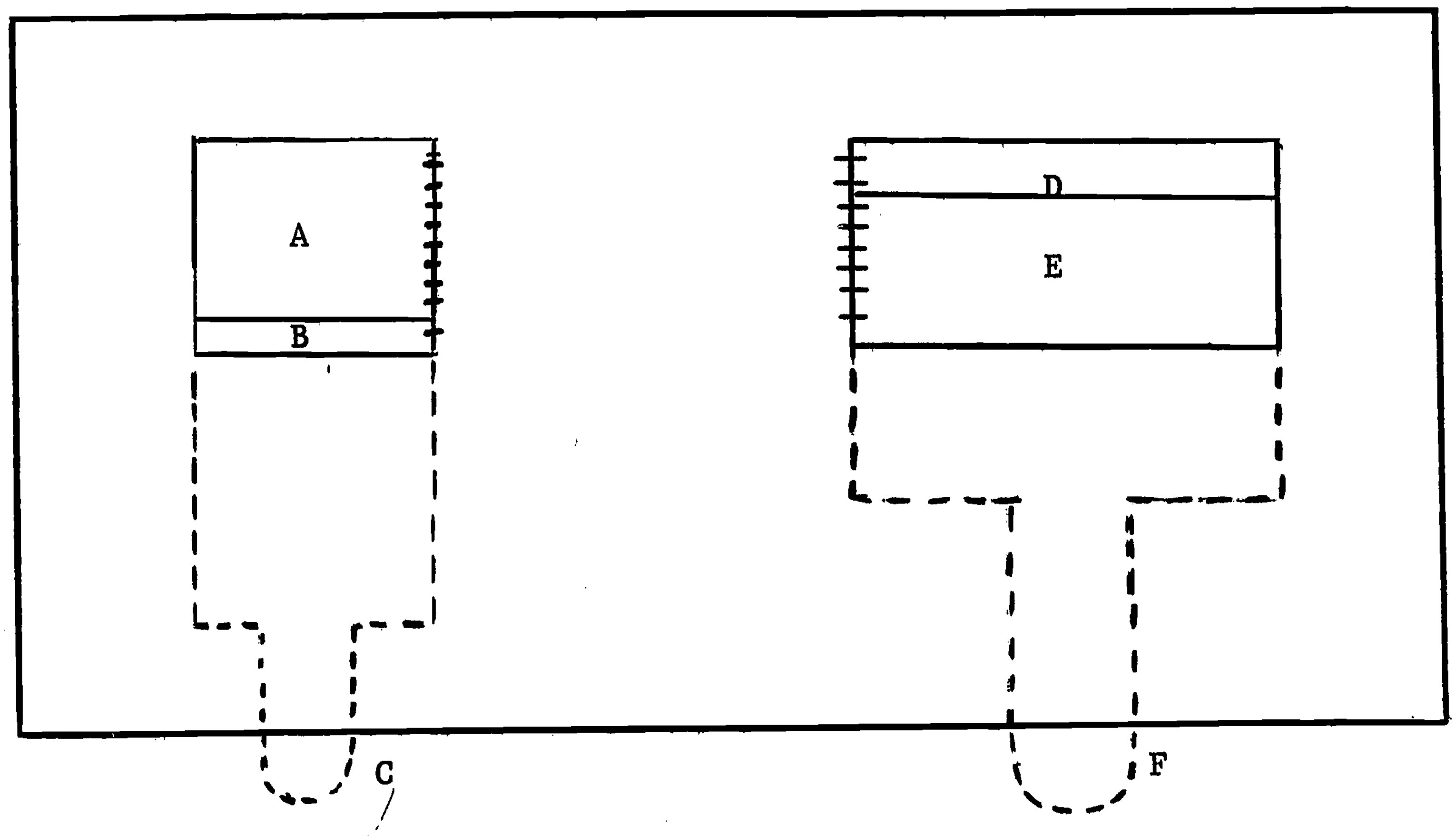


Figure 1
Simulation of Juice Level

A. Cut-out to represent left glass
B. Movable juice strip
C. Operating handle

D. Cut-out to represent right glass
E. Movable juice strip
F. Operating handle

3. Manipulate both glasses of model and explain, "These are like glasses. This orange is the juice. Watch....up to the top. Is this glass full or empty?...Down to the bottom. Is this glass full or empty?"

   Fill left glass to the sixth line from the top. "See how much juice I'm putting in your glass? Now if you poured all of this juice into my glass over here, how much juice would I have? Would I have just as much juice as you had?" If not, "Which glass would have more juice?"

   Same   L more   R more

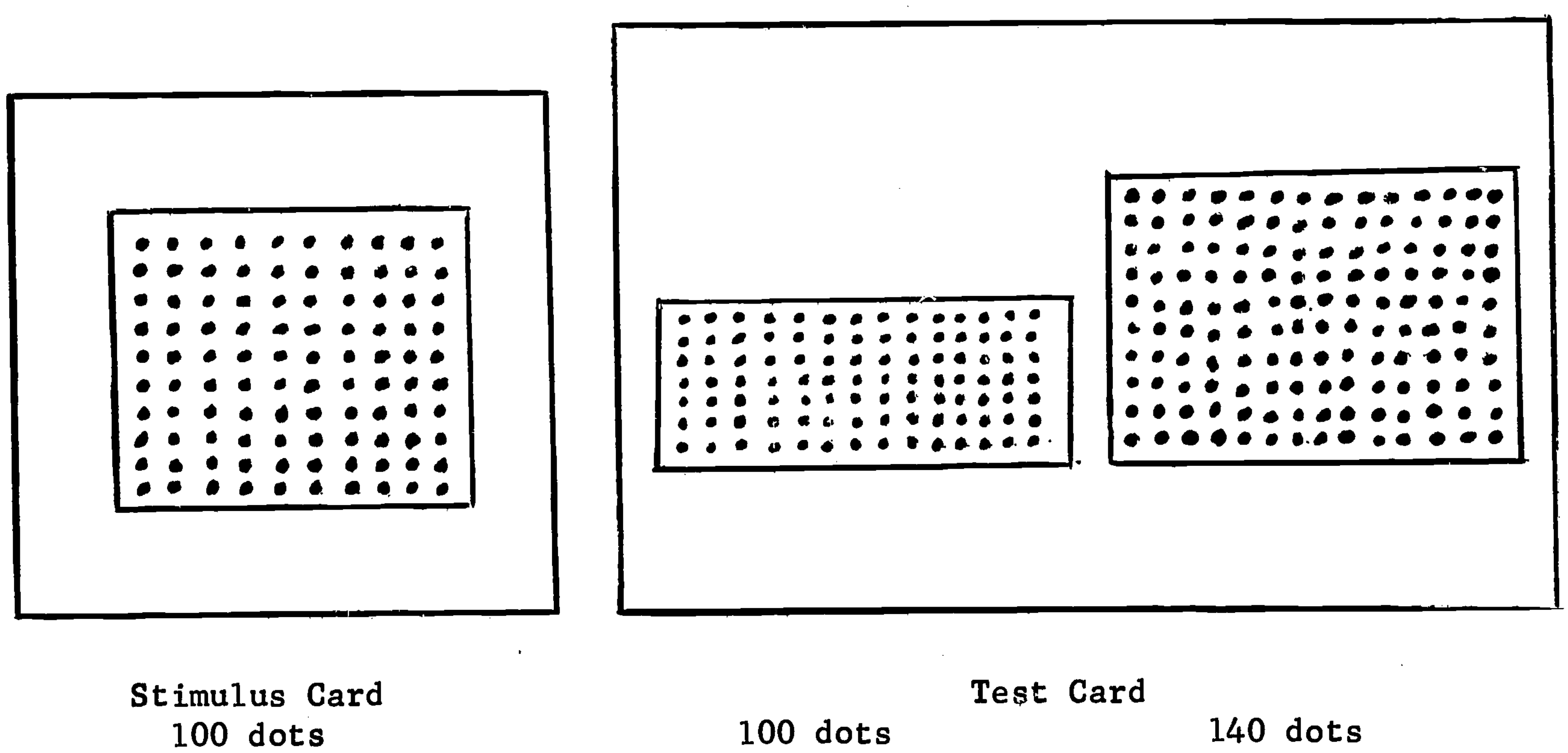
4. "If I poured all of this juice into my glass, how much juice would I have? Show me...Show me how my glass would look."

   Between 5 and 7 / Same   Above 5 / More   Below 7 / Less

5. Adjust left glass to the fourth line from the top. Instruct, "Show me how this glass (R) would look if it had just as much juice as this glass (L)."

Between 3 and 5	Above 3	Below 5
Same	More	Less

The stimulus card for Item 6 displays a rectangle the same color and shape as the left juice had been in Item 4, on the card are about 100 equally spaced dots. The test card displays two dotted rectangles, one of which is the dimensions of the right juice strip if it were properly compensated in Item 4; the other of which is the same width as the stimulus rectangle but greater in height (the dimensions of the right juice strip in Item 4 if it were raised to the same level as the left). The stimulus cards for Item 6 are illustrated in Figure 2.



(paint cards will display patches that are the same shape and color)

Figure 2
Conservation By Dots

6. Present card 3a. Explain, "Take a good look at how many dots there are on this orange patch. I'm going to see if you can find another patch with just as many dots."

   Allow the child to study the card for ten seconds. Then present card 3b horizontally. "Which one of these orange patches has just as many dots as the patch you just looked at?"

   140 dot patch   100 dot patch

Item 7 was presented in connection with two cards, the stimulus card (which displayed a rectangle the same color and shape as the juice strip in the left glass for Item 4) and the test card (which displayed two rectangles). One of these was the same color and shape as the right juice strip would be if it were raised to the same level as the level of the left strip in Item 4. The other was an appropriately compensated rectangle having about the same area as the rectangle on the stimulus card, a rectangle about the same shape and color as the right juice strip would be in Item 4 if the "amount" in the right glass (not the level) were the same as the amount in the left.

7. Present card 6a horizontally. "I want to paint this orange patch <u>red</u>. Take a good look at the patch and figure out how much paint I'd need."

   Present card 6b vertically. "One of these orange patches would need just as much red paint as the patch just looked at. Show me which one."

   140 patch   100 patch

Items 8 and 10 were presented in connection with two dowels, both the same length. One dowel, however, was greater in diameter than the other.

8. Grind small dowel rod in pencil sharpener. Ask, "What happens to this rod as I keep turning? Does it become longer or shorter?...And what happens to this pile of dust? Does it become bigger or smaller? Correct wrong responses.

   Present a thick rod and a thin one side by side, standing up. Ask, "Which rod would make the bigger pile of dust if I ground it with the pencil sharpener?...This one,..or this one?"

   Thick rod Thin rod

9. Stand in front of a mark on the wall that is on a level with the top of your head when you stand up straight. Explain, "See how tall I am when I stand up as tall as I can? I come up to this mark."

   Squat down and say, "See how tall I am now?" Mark the spot, then ask, "Show me how tall I'd be if I stood up as tall as I can." Hand the child pointer. Ask to clarify uncertain responses. "Do you want it below the mark?" or, "Do you want it on the mark?" etc.

   Above mark On mark Below mark

10. Stand a thin dowel and a thick dowel side by side. Explain, "Pretend that these are pieces of ice. This one is a piece of ice...And this one is a piece of ice. Now if they melt, will one of them make a bigger puddle of water than the other?"

   Y N DK

   "Which will make the bigger puddle of water?" (Asked for Y)

   Thick rod Thin rod

<u>Rationale For Conservation Items</u>

The various items were constructed in such a way that different aspects of the conservation response could be tested.

1. <u>The role of the sensory cues</u>. The Piagetian interpretation suggests that the non-conserving child is unduly influenced by sensory cues. Item 2 requires the child to predict what will happen when the

transformation is reversed and the contents of the wide glass is returned to the original glass. If sensory cues are important, the child should base his prediction on what is perceptually present, not on what had been.

Item 9 is analogous to 2, in that it requires the child to reverse a transformation. If the sensory past influences the child's judgment, then it is not reasonable to conclude that he is unduly influenced by the sensory present. Furthermore, comparison of performance on items 2 and 9 would indicate whether the child is applying an analogous reasoning pattern to analogous situations.

Items 3, 4, 5, 8, and 10 require the child to make judgments about the concept "liquid", not in connection with the perception of liquids but in connection with the perception of solid objects. If the child is unduly influenced by the sensory present, he should be influenced by the sensory, not by the conceptual cues. If, in one case, he asserts that two rectangular-like solid objects of the same height but of different widths are not the same in amount, then he should be expected to produce a consistent response in other cases that are perceptually similar. If the child's responses change <u>according to what the rectangle is supposed to be</u>, then the inference would be that he is influenced by concept, not by sensory, cues.

2. <u>The ability to reverse</u>. Two analogous items in the Inventory test the ability of the child to reverse operations--items 2 and 9. Although the items are analogous, the verbal conventions associated with each are different and represent a possible source of confusion. Item 9 is based on the idea that when somebody squats down, he is "shorter" than he is when he stands up. A simple measurement discloses that he gets shorter and taller. The reasoning that ensues, therefore, holds that if

the action of squatting were reversed, he would again assume his original height. The verbal conventions associated with liquids are somewhat different: there is a contradiction involved in saying that a liquid becomes "less" when it is alalogous to a squatting position and "more" when the operation is reversed.

If the child deals with these problems analogously, getting item 9 correct and handling items 1 and 2 in an analogous manner (indicating that the operation is reversible but that the amount change), several conclusions would follow: a) The preoperational kindergarten child is able to handle reversibility. b) The source of his difficulty stems from the application of wrong sets of rules. This would imply that one factor impeding his performance is specific knowledge about the properties of liquids and about verbal conventions, not a cognitive structural factor.

3. Atomism. Piaget suggests (1941) that one of the reasons for the child's failing to conserve volume earlier than he does is that he does not understand that the matter is composed of particles that are fixed in size. What is the role of atomism in handling liquid-transfer problems? Obviously, unless the child understands that the units of amount are fixed, he is not in good position to treat liquids as an instance of fixed-unit things. On the other hand, if the child's development is delayed merely because he supposes that liquids grow and shrink, then it would not seem reasonable to base conclusions about the child's cognitive structure on his ability to conserve or not conserve liquid amounts.

The Inventory is designed to test the child's ability to handle fixed-unit reasoning and to apply it to liquids. Items 8 and 10 establish a baseline of the child's awareness of the basic fixed-unit principle: if two objects are the same in one dimension, but different in another, they cannot contain the same amount of stuff. Item 1 tests a corollary of this rule: If the wider object were made as high as the narrower object, they would not contain the same amount of stuff; however, the wider one is not as high. Items 4 and 5 allow the child to demonstrate whether or not he will use the fixed-unit principle (if they are the same height but different widths, they cannot contain the same amount) to representations of liquids. The child's performance on items 1, 4, 5, 8, and 10, therefore, would provide both an indication of the child's cognitive ability and his specific knowledge about liquids.

4. Multiplication of relations. A simplified test of the child's ability to multiply is provided in items 8 and 10. He must be able to judge the bigger dowel by attending to both height and width. Both dowels are equated in height; therefore, the difference in width must be the variable that determines total amount (high and wide vs high and not wide).

5. Confusion of level with amount. The response of children on items 8 and 10 compared with performance in handling liquids and representations of liquids (1, 2, 3, 4, 5) provides some indication of possible confusion of amount with level. The child's experience with solid objects may prompt a different rule than his experience with liquids. The child's experience with liquids is centered around comsumption, the rule of which can be expressed solely in terms of level: the lower the level, the less the amount of liquid. Width is not a factor. If the non-conserving child operates according to the principle of consumption, one would expect him to a) ignore the width of the container and base judgment solely on level; and b) therefore use a different pattern of reasoning in dealing with liquids than is used in connection with solid objects

that have not been experienced in "consumption" but in "transformational" situations (items 8 and 10). The consumption principal would lead the child to treat liquids as if they were expandable and compressable.

The Training Program.

The fifteen children in the experimental training group attended four sessions during which they learned about the way in which the compensation principle applied to two-dimensional rectangles. The emphasis was on observation, not on active participation. The sessions lasted from 15-20 minutes. A fifth session followed, during which children were individually presented with two criterion problems. These were similar to examples presented during the training sessions. All children passed the training criterion (two children requiring some additional instruction during the session) and training was terminated at this time. The total training time of the four sessions was 54 minutes.

Conceptual Independence. The tasks presented to the children concentrated on two major themes. The first of these was the notion of independence of conceptual dimensions. The experimental subjects were shown that certain observations were independent of others. Two balls that are not the same color may be the same size; two balls that are not the same size may be the same color. Two glasses that are not the same height may have the same liquid level; two glasses that do not have the same liquid level may be the same height. Two pockets that are not the same size may each contain the same number of coins; two pockets that do not each contain the same amount of coins may be the same size.

Compensation. The second major training theme was the compensation argument--the idea that, when dealing with fixed units, a change in one dimension (width or height) is accompanied by a compensating change in the other dimension, The starting point was a knowledge of compensation already in the repertoire of the children, the shape changes that occur when a rectangular object is "tipped" 90°.

Obviously, the object remains the same; obviously, the interior units are fixed; obviously, some change in height-width shape will occur. A tall object will get short, a short object will get tall. Children were given practice in predicting what a tipped rectangle would look like. They also worked on analogous tasks, such as showing how much of a wide, tall rectangle could be painted (starting from the bottom) and assuming that the amount of paint available was the same as that used to "paint" a tall, thin rectangle. Table 3 summarizes the tasks and the amount of time devoted to each during the training sessions.

<u>General Principles of Training</u>. 1. The training was based on a deductive, not an inductive procedure, in the sense that the children were not required to formulate the various rules needed to discern relationships. The children were given the rules verbally. The children remained seated, facing the chalkboard throughout the training sessions. From time to time children would have turns at demonstrating something on the chalkboard, but the children spent most of their time in their seats responding to questions posed by the teacher. Unison responses were used more than individual responses. All presentations were highly structured.

At no time during the training sessions did the children see a real vessel of water. At no time was there any discussion about the <u>transfer</u> of liquid from one vessel to another. The only time the children saw an actual transformation was when the teacher demonstrated (during the first training session) that, when an eraser is rotated 90° and

Table 3

Tasks in Training Sessions

	DESCRIPTION OF TASK	TOTAL INSTRUCTION TIME
1. CONCEPTUAL INDEPENDENCE TASKS		
Independence of number and size	Demonstrate that pockets can be bigger in size yet contain the same number of coins	6 min.
Independence of level and size of container	Demonstrate that the level of liquid in a container is independent of the size of the container; the bigger container can have "less juice"	5 min.
Independence of size, shape, and color	Demonstrate that objects can be grouped and regrouped on the basis of the same shape, same color, and same size.	10 min.
2. COMPENSATION TASKS		
The dimensions compensate when a rectangle is rotated	Demonstrate that the same rectangle can be rotated 90° resulting in relative changes in width and height	15 min.
Construction task: Dimensions compensate when units are rearranged	Demonstrate that the "same amount" principle applies to rectangle that is divided into squares	6 min.
Construction task: Dimensions of liquid spread on flat surface compensate	Demonstrate that the "same amount" principle applies when squares are "painted". The area of the painted area remains the same, but the shape may change, the dimensions compensating.	12 min.
	TOTAL:	54 min.

its outline is traced on the board, the resulting rectangles will be relatively different in shape -- so far as height and width are concerned. The total time devoted to this demonstration was not more than two minutes. The eraser demonstration was also the only exposure the children had, during the training sessions, to real concrete objects of any kind. All other "objects" were chalkboard representations of <u>end states</u>. Some tasks involved a "logical" transformation. For example, the children were shown how to <u>figure</u> out how much of a larger rectangle could be painted if given the same amount of paint used to paint a smaller, taller rectangle; but no actual transformation was demonstrated.

Piaget's explanation of cognitive development would imply that the kind of training offered in the present experiment should fail because:

(a) The internalization of actual action is seen as a necessary prerequisite to intellectual growth; no opportunity for internalization was provided by the present training.

(b) Learning is seen to proceed from a manipulation of actual concrete things; however, actual concrete things were not presented in the training sessions.

(c) The conservation response is seen to grow out of the child's increasing awareness of fixed-stages in the shape transformation process--as a movement from end states to process. However, the presentational emphasis of the training was on end states, not on transformations. Therefore the training should tend to reinforce what is seen as a cognitive weakness of the preoperational child--his preoccupation with end states.

2. Analogies. The assumption behind the task selection for this training was that the children already could handle problems that are analogous to conservation problems. The training tasks were designed to articulate this area of analogy, to encourage the children to "put on a different hat" and perhaps to look at liquids as if they were solids and to use the kind of fixed-unit reasoning used to handle problems that obviously involve fixed units.

3. Knowledge. The training attempted to ensure that the children would not fail because of a failure to understand the concepts and skills that are involved in conservation response. Specifically, the training defined the independent nature of such dimensions as bigness, tallness, thickness, level, and amount. This part of the training gave the children practice in focusing on different aspects of physical objects, and attending to the statements that apply to each aspect.

Following the training sessions, the Conservation Inventory and PPVT were again administered. Standard *t* tests were calculated to determine significance of the training program and Chi Square tests were used to evaluate the item by item change on the Conservation Inventory.

RESULTS

The results section will deal first with the patterns of pretest results obtained by the present sample and then deal with the impact of the intervention program.

Table 4 shows a matrix of results obtained by the seventy-two children judged nonconservers at the pretest administration. The first column after the listed items gives the total number of subject who obtained the correct answer to that item. There was a wide diversity of performance on the Inventory items. On items 8, 9, and 10, almost 90% or better of the children showed a clear mastery of these items while less than 20% of the children were successful on items 1, 4, and 5.

The remainder of the rows in Table 4 indicate the percentage of success on other items attained by those students who obtained correct answers on the item in that row. For example, on item #1 seven students obtained a correct answer. Of those students, 71% obtained a correct answer on item #2 while only 29% obtained a correct answer on item #3 and 14% on items 4-7. Some of the patterns that can be noted are that those who get item 4 right tend to get item #5 right but not items #3 and #1. The percentages are controlled somewhat by the total number of correct answers on the item. Since item #1 had only seven correct answers, only seven could have also gotten item #6 right so that a maximum of 25 % could be obtained in that cell opposite item #6. Nevertheless, there do seem to be meaningful patterns of performance here, and these will be presented at a greater length in the Discussion section.

Table 4

Performance By Nonconservers By Item
On Pretest Conservation Inventory

Item	Number Correct (N=72)	1	2	3	4	5	6	7	8	9	10
1	7		71	29	14	14	14	14	71	100	86
2	47	11		51	17	11	38	30	89	91	94
3	34	6	71		6	12	38	26	94	91	97
4	12	8	67	17		50	50	42	83	92	83
5	11	9	45	36	55		36	36	73	82	91
6	28	4	64	46	21	14		50	93	89	96
7	22	5	64	41	23	18	64		95	95	95
8	63	8	67	51	16	13	41	33		90	98
9	65	11	66	48	17	14	40	32	88		92
10	67	9	66	49	15	15	40	31	93	90	

Columns 1–10 are grouped under the heading "Percent with Correct Response by Item".

In terms of total performance, the percentage of successful response presents a pattern of its own. If the items were rearranged according to difficulty, they could be divided into four groups.

	Items	Content	Success
I	8,9,10	Three dimension solid objects	85% or better
II	2,3	Verbal prediction on liquids	45% to 70%
III	6,7	Compensation problems	25% to 40%
IV	1,4,5	Manipulation and prediction of liquid transfer	Under 25%

From these results, it is possible to conclude that children of kindergarten age and average ability have some of the components of conservation concepts even though they fail the liquid conservation task.

Table 5 gives the group results of experimental and control samples on pretest and posttest performance on the Peabody Picture Vocabulary Test and the Conservation Inventory. A period of about four weeks elapsed between the pretest and posttest. It can be noted that no substantial changes took place as a result of the training program or intervention on the Peabody Picture Vocabulary Test (PPVT). The performance of the students remained relatively constant in experimental, control and conserver samples. Since the PPVT requires only the identification of common objects on the basis of an auditory stimulus, there is no reason why specific training of the type applied should be expected to produce any substantial changes.

On the Conservation Inventory, there was a significant difference in performance noted in the experimental sample. The control sample remained relatively consistent during the two testing periods, averaging less than 5 items correct each time. The experimental group showed a significant increase in the number of items correct, from an average of

Table 5

Pretest and Posttest Differences on Peabody Picture Vocabulary Test and Conservation Inventory for Experimental and Control Groups

(Posttest Administered 4 Weeks Following Initial Test)

TEST	EXPERIMENTAL (N=15)		CONTROL (N=15)		CONSERVERS (N=15)	
	Mean	SD	Mean	SD	Mean	SD
Peabody Picture Vocabulary Test						
Pretest MA	76.33	8.82	77.27	9.40	96.80	14.53
Posttest MA	77.20	9.94	80.67	8.00	96.60	15.22
Conservation Inventory						
Pretest	5.07	1.22	4.53	1.51	9.53	.84
Posttest	7.87**	1.77	4.80	1.63	9.20	.99

** Significant at .01 level.

5 to almost 8 items, thus indicating the positive impact of the training program on these students. The older group of conservers showed a consistent performance. On this ten-item test, they averaged over 9 items correct at each administration.

Table 6 gives a more detailed breakdown of the changes by item at pretest and posttest conditions. The McNemar test for calculating significance of change indicated that there were significant forward movement in the experimental sample on Conservation Inventory items 1-5, and these changes were not duplicated in the control sample who remained reasonably constant in their performance on each of the 10 items. Ten of the 15 experimental subjects passed the criterion of conservation on the posttest. None of the controls passed the conservation criterion. The controls still showed an inability to understand the property of liquids as tested by Conservation Inventory items #1, #4, #5 and showed no group improvement on items testing compensation.

It will be recalled that these items deal with liquids or the representation of liquid substances, and so represent a significant change in the cognitive abilities and understanding of the conservation concept as it relates to liquids. No changes would be expected, naturally, on items 8, 9 and 10 since the concepts involved in these items had already been mastered by the students at the pretest level. The only items that failed to change in a positive direction for the experimental group involved items 6 and 7 which are represented by compensation problems. The reasons for this lack of change are discussed in greater detail in the discussion section.

Table 6

Growth In Performance By Item On Basic Concept Test Following Training

ITEM	EXPERIMENTAL (N=15)		CONTROL (N=15)	
	Pre	Post	Pre	Post
1	1	10*	1	1
2	9	15*	7	8
3	5	14**	8	7
4	3	12**	3	3
5	4	12*	2	3
6	5	9	5	6
7	6	6	3	3
8	15	13	12	14
9	14	15	14	13
10	14	12	13	15

* p .05

** p .01

Table 7 gives the individual response of the fifteen experimental and fifteen control children before and after the training program. The group gains of the experimental sample are clearly the result of substantial gains by the majority of children and not merely great improvement in one or two. Over half the sample gained four items or over in the ten item scale, as contrasted to only two of the control group. At the posttest, only one member of the control group had achieved a score of seven while twelve of the experimental group had attained that level. In most instances, it was the failure to solve the compensation problems #6 and #7 that kept experimental children from obtaining a perfect score.

Table 7 also compares responses of partial conservers and nonconservers. There was a slight tendency for the partial conservers to respond to the training more effectively, suggesting that the more one knew about conservation the easier it was to absorb new ideas on the subject. This difference did not reach a statistically significant level. No trends of any sort could be noted between the partial conservers or nonconservers in the control sample.

A running record of student performance was taken during each teaching session by an observer who checked a three point scale on the dimensions of Motivation, Attention Span, Participation and Performance. When the sum of these ratings was intercorrelated with the gain scores of the experimental group for those ten students who had a continuing attandance and ratings for all training sessions, the following relationships were noted:

	r
Motivation vs. Attention Span	.91
Motivation vs. Participation	.82
Attention Span vs. Participation	.75
Gain in Training vs. Performance on Tasks	.59
Motivation vs. Performance on Tasks	.53

Table 7

Individual Changes On Conservation Inventory

PAIR	EXPERIMENTAL			CONTROL		
	Pretest	Posttest	Gain	Pretest	Posttest	Gain
1	4	7	+3	8	6	-2
2	6	10	+4	4	3	-1
3	4	9	+5	5	4	-1
4	5	10	+5	5	4	-1
5	7	8	+1	4	4	-1
6	7	7	0	5	6	+1
7	5	10	+5	3	7	+4
8	5	9	+4	4	4	0
9	4	5	+1	5	6	+1
10	6	10	+4	3	5	+2
	NONCONSERVERS					
11	3	8	+5	5	5	0
12	6	5	-1	1	6	+5
13	6	7	+1	5	3	-2
14	3	8	+5	6	4	-2
15	5	5	0	5	6	+1
Mean	5.07	7.87		4.53	4.80	

The gain scores related to task performance in the training sessions, which would be expected, but not to motivation or attention. Task performance in the training though was related to motivation. The high relationship between motivation, attention span and participation suggests that the observer was really giving a general rating to students' willingness to cooperate and respond. The general effectiveness of a training program as in the present study always will be underestimated if too many unmotivated students are participating. This did not appear to be a major factor in the present study.

CONCLUSIONS

The results of this study indicate, among other things, that a careful distinction needs to be made between validating the behavioral observations of Piaget and his followers regarding conservation in young children and acceptance of the Piagetian conceptual model or explanation for that behavior. This study, like many others, shows that many young children of kindergarten age are confused when faced with tests of conservation of amount. They say first that the amounts are the same and then that they aren't. They become embroiled in contradiction and are confused by the outcome. In contrast, the child who can 'conserve' is confident and consistent in his approach to the same tasks.

The present experiment, even with a small sample, suggests that there are alternative explanations for the child's behavior that are more consistent with available data. For example, the Piaget contention that concrete manipulation is necessary for learning the conservation response is not accurate since, in this study, significant change and learning was achieved through a presentation in which:

a. The children did not manipulate actual objects.

b. The children did not work on physical process, but on logical process, with emphasis on end states, not on the sequence of transformation.

c. The children learned rules that apply to a class of objects, not mere concrete experiences.

d. The children worked from representations of concrete objects.

The inability of the child to solve the traditional tasks of liquid transfer has been interpreted to mean that there are deficiencies in the child's cognitive ability to multiply relations, to understand reversibility, or to attend to process rather than end states. However, a more parsimonious answer would be that the 'nonconserver' merely misunderstands the properties of liquids.

It would appear that the child develops hypotheses about such properties that extend from primitive to adequate. He tends to remain at one stage of explanation until evidence is accumulated that makes the hypotheses untenable at which time he tends to reformulate his ideas to incorporate the new data. In this regard, the child operates not unlike the scientist pursuing the most adequate and parsimonious explanation for the data in his environment.

While the dissonant data which forces such a reformulation can be accumulated by experience plus a growing intellectual maturity to process information, it would also seem quite possible, as in this study, to program the experiences so that the child can rather quickly move through the stages until he possesses an adequate concept of liquidity.

The following stages would seem identifiable in this process of increasing sophistication of the concept of liquid.

I. <u>Amount Varies as the Level of Liquid</u>.

The naive nonconserver of 5-7 years does not know about the nature of liquids. His experience has centered around consumption, not around transfer. The principle that applies to the consumption situation is simply: THE HIGHER THE LEVEL, THE MORE THERE IS. (Conservation Inventory item #1) By applying the converse of this rule he is led to the conclusion that liquids are expandable (Conservation Inventory item #2). THE AMOUNT

OF LIQUID INCREASES AND DECREASES AS THE LEVEL CHANGES.

The child that is completely naive about liquid transfer situations will find himself making predictions that are not verified. If he says that the wider container has less, or it will have less when its contents are returned to the original vessel, his predictions will not be verified.

II. Liquids Expand and Contract as Situation Requires.

To resolve the difficulty caused by the wrong predictions above, the child uses the reversibility rule that applies to other familiar solid objects (Conservation Inventory item #9). By applying this rule to the liquid transfer situation (which 47 of the children apparently did on pretest), the child follows a procedure used in familiar shape-change situations (with all but 4 of the 47 children who got item #2 correct also getting analogous item #9 correct).

Now no contradiction results unless consumption is combined with the transfer of juice. Merely transferring juice from container to container presents no problem for the child and poses no contradictions. He indicates on item #1 that the amounts are not the same; he then indicates that if the liquid were transferred back into the original container, the amount in the original glasses would again be as it had been in the original presentation. Such transferring can go on indefinitely without creating a contradiction.

The child sees liquids as things that expand and contract according to certain situational rules. When a particular situation is revisited, the liquid will behave as it had previously in that situation--expanding or contracting. The child in this stage indicates on Conservation

Inventory item #3 that the amounts will be the same; he then proceeds to show on items #4 and #5 that the levels are the same. Again, no contradiction occurs.

Furthermore, the notion that liquids are expandable is consistent with observation. Liquids assume the shape of any container; they are flexible. When liquid emerges from the garden sprinkler, it seems to expand and blossom. It also has a soft, flexible feel, related to the sensation that one has from other expandable things.

The only way to create a contradiction is to show the child that there is a discrepancy between consumption and the assumption that liquids are expandable. This is done by pointing out that the amount of liquid judged less by the child after transfer is actually the same, if it is consumed at that time, as it would be if consumed after transfer to the original container. Such a contradiction will not be revealed by mere transfer experiments.

III. Liquids Can Be Treated as Solids: Amounts Are Invariant.

After the child finds out that there is a discrepancy between transfer and consumption, he learns that the amount is an invariant which means that he must treat liquids as if they were solids.

We can infer that he has learned the basic fixed-unit rule:

IF THE AMOUNTS ARE THE SAME, THEY WILL REMAIN THE SAME REGARDLESS OF HOW THE TRANSFORMATIONS LOOK.

or

IGNORE WHAT THEY LOOK LIKE: JUST REMEMBER THAT IF THE AMOUNTS ARE THE SAME, THEY WILL REMAIN THE SAME THROUGHOUT ANY TRANSFER OPERATION.

The child who uses this rule would be judged as a conserver on the basis of traditional tests of conservation! He does not use compensation reasoning, and he has no need for compensation reasoning. No longer does he get fooled by indicating that the wider glass has less; if it had the same amount before, it has the same now.

Apparently the child can understand this rule on a verbal or a figural level, but be unable to coordinate the two. For example, a child may get Conservation items #1 and #2 correct but miss items #3, #4 and #5. In other words, he has learned to deal verbally with liquid transformations, but he is unable to <u>construct</u> the transformations in a figural sense. When the child is asked whether the right glass on the model will have just as much juice as the left after transfer, his rule breaks down because he must predict an outcome instead of simply observing an outcome. He has learned that liquids do strange things, and he knows that the right glass will somehow look different from the left, but he does not know how and he gets items #4 and #5 wrong. He knows little about the appearance of juice after transfer.

On the other hand, the child may have the figural image of how the transfer would look but be unable to coordinate it with the proper verbal statement. He is going the opposite route to the child noted above. This child is able to show what the transfers will look like (items #4 and #5), but he misses items #1 and #3. Of those twelve children who could show what the transfers would look like in item #4, ten failed on item #3, and eleven failed item #1. These children are vulnerable to consumption-transfer contradictions.

IV. Coordination of Verbal Statement with Figural Observation.

In this stage, the child learns to coordinate verbal responses with figural observations. The child can arrive at Stage IV by several different routes and possible combinations of those suggested in Stage III. (Since the child probably has "islands" of understanding, and probably operates in a world of pervasive verbal confusion). The Stage IV child has learned that amount is an invariant and that the shape changes are similar to those observed with solids. After learning the rule: "They are the same; don't pay any attention to how they look," the Stage III Verbal child is in a position to attend to the shape changes. The Stage III Figural child must learn, in addition to his knowledge of shape changes, the rule about the fixed-unit nature of liquids. Without this rule, he will never be able to conserve in the comprehensive sense of the concept.

V. Conservation and Compensation.

Stage V: The Stage V child, as seen in Table 5, tends to get all of the items right. He can apply the compensation principle to liquids, to representations of liquids, and to dot patterns. Eight of the 15 conserving children got all of the Inventory items correct. This means that the conserving child is able to apply compensation reasoning even to the most difficult problems on the Inventory, problems #6 and #7, which seemed to be a chance item for many of the nonconservers. Items 6 and 7 (the dot and the paint problems) require the child to use compensation reasoning in a situation in which no "construction" is implied, in other words, in which both dimensions change immediately and simultaneously.

Stage V children, therefore, are conservers in the sense referred to by Piaget. They can use compensation reasoning to construct the outcome of a transfer (items 4 and 5), and they can use compensation reasoning to handle the more complicated, simultaneous version (items 6 and 7).

Educational Implications.

One of Piaget's leading interpreters (Flavel, 1963) suggests that there are three major applications of his theories that can be made to the educational setting. The first of these lies in its potential use in diagnosing or placing children in proper settings through cognitive tests such as those on conservation. The second deals with curriculum development where certain materials or learnings would be delayed or repositioned in the educational program on the basis of Piaget findings. The third application would be to take advantage of what has been learned about the learning process and to adapt the learning environment and teaching methods accordingly.

There would seem to be some potential danger in accepting the Piaget observations on conservation as the basis for educational planning for primary age children. If the fact of nonconservation is seen as an indicator of general intellectual immaturity and inability to deal with problems that require concrete operations, then the entire character and form of the educational program can be influenced. Certain kinds of tasks and problems would be withheld until the child is 'ready' or 'mature'.

There is a certain amount of self-fulfilling prophecy involved here. The basic difficulty in using observations of children's behavior as a basis for educational planning is that such observations are valid only for the situations that currently prevail. One would have to say that American children mature very slowly in their ability to kick a round ball with their feet. European children, while 'maturing' more rapidly in this dimension, seem unaccountably behind American children in the eye-hand coordination measured by meeting a round ball with a long stick. Few educators would have many doubts about how to redress these inequalities, but such adjustments seem harder to accept in the intellectual dimension.

If we do not, as educators, provide the young child with experiences or programmed lessons which stimulate the child to think, then we will have predicted correctly. He will not be thinking, or rather will be thinking only about the environment that he can sense. If that environment is free from intellectual stimulation, he certainly will appear to be the cognitively immature child that our predictions had suggested. Would the Piaget approach have predicted, for example, that primary age children could learn important elements of economics, set theory, physics, etc. which the new curricula movements have demonstrated?

It would appear that we would be better off taking other Piaget virtues for our guide such as his detailed observation of the child's behavior in trying to solve a task or paradox and his attempt to identify sequential developmental stages which can provide important guides to teachers. As in this study, a breakdown and analysis of the concept to be taught into its component parts is a necessary first step. If the child reveals ignorance of some of the components or if his reactions to a problem reveal that he has formulated an inadequate hypothesis concerning the concept, then the teacher knows what has to be done.

One essential requisite for such a program is that the teacher have a thorough understanding of the conceptual structure and underpinnings of the ideas or concepts she is trying to teach. The ability to break down a concept such as conservation or neighbor or community into its key parts and, through such analysis, to be able to stimulate the thinking of children is a very important one and a much neglected area of teacher training. It is doubtful if the teacher can provide the student with a cognitive structure of greater complexity than she herself can understand and grasp.

Above all, the ability in this study to teach concepts surrounding conservation in a very limited time span should provide educators with a type of restrained optimism. They should realize that the last word has not been said on what young children can learn. What they will learn depends, in part, on the ingenuity of teachers in organizing appropriate learning programs or sequences.

SUMMARY

The purpose of the present study was to explore the Piaget concept of conservation with regard to the child's concept of the property of liquids. Forty-five children (CA 5-0 to 7-2) were given a Conservation Inventory, devised for the present study, to provide a broader index of the child's understanding of conservation. This inventory employed tasks using solid objects, verbal prediction of liquid behavior, compensation problems and the manipulation and prediction of liquid transfer. Each of the children was administered the Peabody Picture Vocabulary Test (PPVT) in order to establish mental competence and level.

Thirty children were identified as nonconservers as a result of the pretests and divided into fifteen pairs matched on Mental Age scores on the PPVT. The fifteen experimental children were given five days of training sessions lasting from 15-20 minutes each. The focus of these training sessions was upon establishing in the child the ideas of conceptual independence (i.e. two balls may be of the same size but not the same color) and compensation (i.e. when dealing with fixed units, a change in one dimension, such as width or height, is accompanied by a compensating change in the other dimension). These lessons were delivered in small group instructional sessions with the emphasis on observation but not on active student participation.

Following the training sessions, the Conservation Inventory and the PPVT were readministered to experimental and control groups. The experimental group showed a significant improvement on the Conservation Inventory indicating a more complete mastery of the property of liquids and ability to predict the behavior of liquids under varying circumstances.

No changes were noted on the PPVT.

These results bring into question some of the Piagetian ideas on how conservation ideas are developed since (a) the experimental children did not manipulate actual objects, (b) the instruction emphasized logical end states instead of the sequence of transformation, and (c) the experimental children mastered rules applying to classes of objects. Further, the question was raised whether the conservation construct, built mainly on the confusion children show in liquid transfer experiments, really represents a key aspect of the concrete operations stage or is, in reality, merely some inadequate childhood hypothesizing on the specific properties of liquids.

Some of the specific hypotheses these children appeared to develop to explain liquid transfer problems were, in order of complexity,

1. Amount varies as the level of liquid varies.
2. Liquids expand and contract as situation requires.
3. Liquids can be treated as solids: amounts are invariant.
4. The use of compensation reasoning to explain liquid transfers and simultaneous shifts in two dimensions.

As experience disproves each of the hypotheses of the child, he formed another which incorporates the new data. While the new data can and does come through increasing age and experience, it can also come through a systematic training program of short duration as applied in the present study.

The educational implications of the present study are that conservation, or more accurately those properties of liquids that have been assumed to stand for conservation, can be taught through instruction. There is no need for educators to wait passively for the child to reach the magic point of conservation mastery before introducing mental tasks that require logical thinking. There is a strong element of self-fulfilling prophecy in predicting that a child will not show logical thinking before a certain age and then to prove yourself correct by seeing to it that any instructional materials that could advance that magic age level are kept from the child.

If concepts and processes are broken into their component parts, it seems possible to present these parts systematically so that the young child masters the larger concept or process. Such task analysis and concept disassembly would seem to be a major and important part in the development of preschool curriculum which would have as its goal the development of conceptual foundations for both the advantaged and disadvantaged child. The present study represents one of many that indicate that the learning of young children is a function of both maturation and his interaction with his environment. The productive manipulation of that environment would seem to provide one major emphasis for educators in the immediate future.

APPENDIX A

The Basic Concept Test

1. Present two cards, one yellow and one red. Identify the cards; be careful not to use the word "and". "This card is red...This card is yellow." Place the cards beyond the child's reach and instruct him to, "Give me the yellow <u>and</u> the red card."

pass fail

2a. Present a third card (blue). Place all cards side-by-side. Tell the child to, "Give me the red card <u>or</u> the yellow card <u>or</u> the blue card." You may have to restrain the child from responding until you have finished your statement.

pass fail

2b. If the child passes 2a, refer to the two remaining cards and instruct the child to, "Give me the _____ card <u>or</u> the _____ card," naming the remaining cards in the reverse order from the 2a presentation.

pass fail

3. Present a yellow card. Tell the child, "I want you to show me a card that is the same color as this one." Show him three cards: a yellow card of a different shape, a blue card of the same shape, and a blue card of a different shape.

pass fail

4a. Present two piles of sand, one much larger than the other. Identify each as a pile of sand. "This is a pile of sand... This is a pile of sand." Then ask, "Which pile has more sand in it?"

pass fail

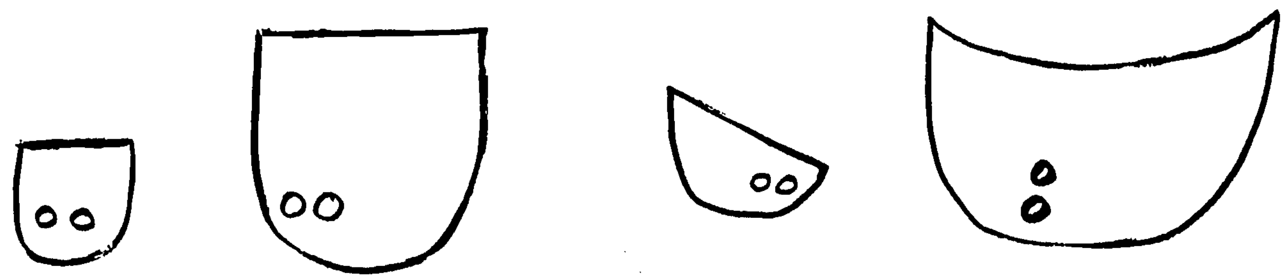
4b. Ask, "Which pile has less sand in it?"

pass fail

APPENDIX B

Specific Training Tasks Used In Present Experiment

1. Independence of number and size (presented during session 1 only). For the basic presentation, the teacher drew four pockets of different sizes on the board, each pocket containing two coins.



The teacher asked, "Which pocket is the biggest?" after which he referred to each pocket in turn and asked, "Is this pocket the biggest?" Next, the teacher asked, "Which pocket is the smallest?" and followed the question by referring to each pocket and asking, "Is this pocket the smallest?"

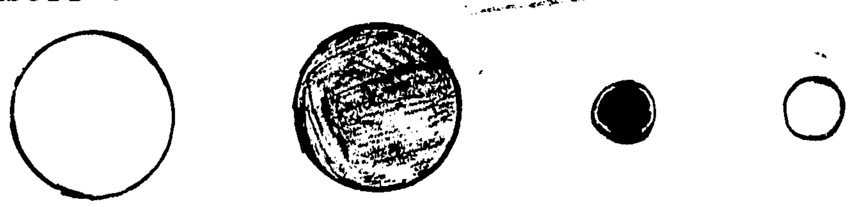
The teacher then pointed to each pocket in turn and asked, "How many pennies does this pocket have?" After referring to each pocket, the teacher asked, "Which pocket has the most pennies?" He corrected the mistakes of children by pointing to the pocket they suggested and asking, "How many does this pocket have?...And how many does this little pocket have?...This one has two pennies, and this one has two pennies. They have the same number of pennies -- two." To test the children's awareness of the concept, the teacher erased the original pockets and drew two more, one of which was considerably larger than the other, warning the children that he was going to fool them. He drew three pennies in each pocket and asked, "Which pocket is the biggest? Which pocket has the most pennies?" The teacher quickly presented other examples in which the biggest pocket contained fewer pennies.

2. Independence of level and size of container. (presented during session 1 only). This task is a simple extension of the pocket task; it deals with levels instead of numbers. The teacher drew two containers on the chalkboard (tracing around an eraser to be sure that they would be the same width and to help stimulate the analogy between solids and liquids). He drew one of the glasses taller than the other. He then chalked in the same level of liquid for each glass.

He used the same procedure as that employed in connection with the coins and the pockets. He first asked which glass was the biggest. He then followed with yes-no questions, pointing to each glass and asking, "Is this glass the biggest?" Finally, he asked, "Which glass has the most juice in it?... Neither. They are the same." He asked yes-no questions about each glass. "Does this glass have more juice than that glass?"...No. Does this glass have less juice than that glass?...No. Does this glass have the same amount of juice as that glass? Yes, this glass has just as much juice as that glass." He presented the question set several times before changing the example by erasing part of the juice column in the taller glass. He presented the original questions, first those about the size of the glasses. "Is this glass bigger?"...Then about the amount of the juice, "Does this glass have more juice in it?" After asking the questions about both glasses, he asked children to produce the appropriate statements. He would point to one of the glasses and say, "Tell me about this glass." (If the child failed to respond, he would follow with more specific questions about bigness and amount. "Is this glass bigger?...Does this glass have more juice?") After both statements were produced (This glass is taller. This glass has less juice), members of the class were called upon individually to procude such statements in response to various presentations. The teacher would change the order in which the statements were presented by giving one of the statements and calling on one of the children to produce the other. "This glass is shorter than this glass. But what about the juice in this glass?..."

The teacher presented three or four different examples. In every case the glasses differed only in height, not width. There was no attempt to teach anything about compensating changes merely to sharpen understanding of the independence of container height and liquid height.

3. Independence of size, shape, and color (presented during sessions 1, 2, and 4). The teacher presented a row of circles on the chalkboard. The various members differed in size and color.



The teacher first asked the children to identify the various objects. "This is a what?...This is a circle. What bout the next one? Is it a circle?" After identifying all of the objects, he pointed to the left circle and asked the children to "Find the one that's the same color as this one." He followed by articulating the steps involved in producing the judgment of sameness, asking a yes-no question in connection with each of the circles, starting with the circle that is second from the left. "Is this circle the same color as that one? This one is white?

Is that one white? No, so are they the same color?...They are not the same color. What about this next one? This one is white and that one is not white. Are they the same? They are not the same. What about the last one? Is it the same color as that one? This one is white and that one is white. White--white. They are the same color." The procedure is designed to demonstrate that two things are the same if one can produce the same statement about each.

Next, the teacher asked the children to find a circle that is the same size as the first. He followed with the articulation procedure, referring to each of the other circles and asking the question, "Is this circle the same size as that one?" demonstrating the size by cupping his hands around each circle and comparing the cut to the original circle.

Finally, he asked the children to find the circle that is the same size and the same color as the first circle. The articulation procedure for this task involves asking two questions and answering them both with "yes". The teacher demonstrated how this process works by referring to each circle in turn and asking the question pair, "Is this one the same color?...Is this one the same size?" Whenever one of the questions is answered "no" the teacher would present the and question and show why the criteria it imposes are not satisfied. "Is this one the same color and the same size?...No, because this one is not the same size?" "Is this one the same color and the same size? No. Why? Because this one is not the same color. This one is green. That one is white."

The task was presented in different manners. Sometimes a mixture of squares and circles of various sizes were presented; sometimes the task was phrased slightly differently. "Find the one that is just like this one...this big and this color." When the task was presented in the sessions following session 1, the children were held increasingly responsible for the verbalization of the statements.

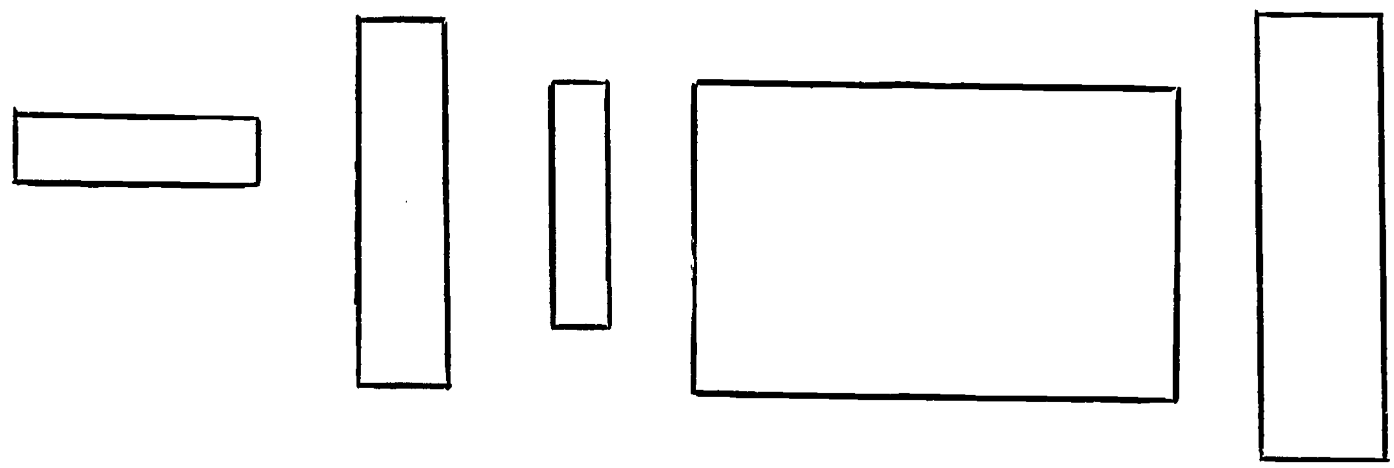
> "If it's the same color as this one, what color does it have to be?"
>
> "If it's the same size as this one, how big does it have to be?"
>
> "Can it be this big?...No? Why not?"

4. Dimensions compensate when a rectangle is rotated (presented during sessions 1, 3, and 4). This task is obliquely related to Task 3 in that both involve an and conclusion. In both tasks the child must produce something of compound observation. In the present task, the observation takes the form of a statement about the height of this rectangle and a statement about the width. "When I tip this box on its side, what will it look like? Will it look bigger this way (indicating height)? Will it look bigger this way (indicating width)?"

During the initial demonstration, the teacher traced around the same eraser as it was held in a vertical and horizontal orientation. He concealed his activity from the children. Then he asked, "Which of these boxes is longest this way (cupping hands over vertical sides and spreading hands horizontally to indicate variation in horizontal dimension)? Which box is the longest this way (cupping hands over the horizontal sides and spreading hands to indicate variation in vertical dimension)?" After establishing that each of the rectangles was longer than the other in one dimension, the teacher pointed to one of the boxes and asked, "Is this box bigger than that box?" Most of the children indicated that the taller box was bigger than the other. The teacher acted quite amused. "Oh, I really tricked you on that one." He then proceeded to let the children in on the joke. "They are just the same size and I can prove it." He took the eraser and showed that by tracing around it when it was "standing up" one of the rectangles was formed , while the other could be formed simply by rotating the eraser 90°. "Which one is bigger? They are the same. One is standing up and the other is lying down." The children seemed to enjoy this joke.

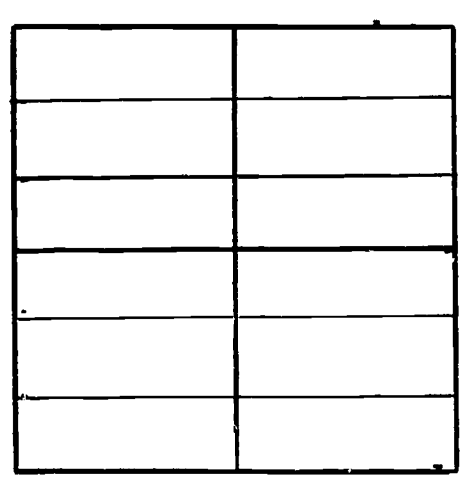
The teacher then gave the children practice in describing the changes in height and width that occur when the rectangle is tipped. "What happens this way (referring to width)? Will it get longer this way when it lays down?...Look, it will get longer. What about this way (referring to height)? Will it get longer or shorter this way?...Look, it will get shorter. That's the rule, <u>if it gets longer this way, it has to get shorter this way</u>." The children were required to repeat the rule many times.

After the initial demonstration, the eraser was not used and the children were not shown how the rectangles would look when they were tipped. The children had to imagine what the rectangle would look like. The teacher presented a series of rectangles:



He asked the children to predict, "What is this rectangle going to look like when I tip it over? Will it get longer this way (referring to the width)? Will it get longer this way (referring to the height)? It will get longer this way and shorter this way." The children were called on individually to supply both statements of change for various rectangles. After the production of the statement, the other children in the class were required to repeat the statement and the rule, "If it gets longer this way...it gets shorter this way." The teacher "tried to catch" the children on the questions. "When this box is tipped over, will it be bigger than it is now?...Will it be smaller than it is now?...Will it be the same size as it is now? Sure, it's the same box."

5. Dimensions compensate when the units are rearranged (presented during sessions 1, 2, 3, and 4). The basic presentation involved a drawing of 12 rectangles in a vertical row. The children first counted the "boxes". The teacher explained, "I want to pile them up in a different way. When I pile them up in a different way, will there be more boxes?...Less boxes?...How many boxes? Yes, I'll still have 12 boxes." The teacher asked the children to apply the compensation rule and tell what the boxes would look like when they were rearranged. "If I pile these blocks up a different way, will the pile get longer this way (height)? No, it can't. Will it get longer this way (width)? And if it gets longer this way (width), what's going to happen this way? Yes, it will get shorter. Say the rule with me: If it gets longer this way, it get's shorter this way." The top six blocks were erased and placed next to the bottom six as shown in the illustration.

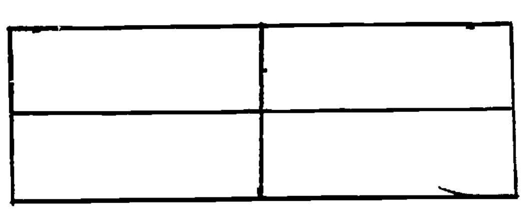


The children were again asked to tell what had happened. "What happened this way (height)? Did the pile get longer or shorter?...And what happened this way (width)? Did the pile get longer or shorter?... What's the rule? If it gets longer this way..." "How many blocks are there?...Still 12."

The process was repeated. The top four blocks were erased and placed next to the other two rows. "Piling up a different way. What happened? Did the pile get longer or shorter this way?...And what about the other way? Did it get longer or shorter?..."

The process was repeated again, again, and again, until there was one horizontal row of 12 boxes. The teacher asked the same questions after each rearrangement, including a question about the number of blocks. When the single horizontal row had been achieved, the teacher asked, "And what would happen if I tipped this pile of boxes and stood it up?... That's right, I'd have the pile I started out with."

The task was repeated, starting with a different number of boxes, presented in either a horizontal or vertical row. Variations of the task were introduced which involved only a single rearrangement of boxes. For example, four boxes were presented in a horizontal row. They were counted and then repiled, the first two being erased and placed (horizontally) on top of the remaining row as illustrated below.

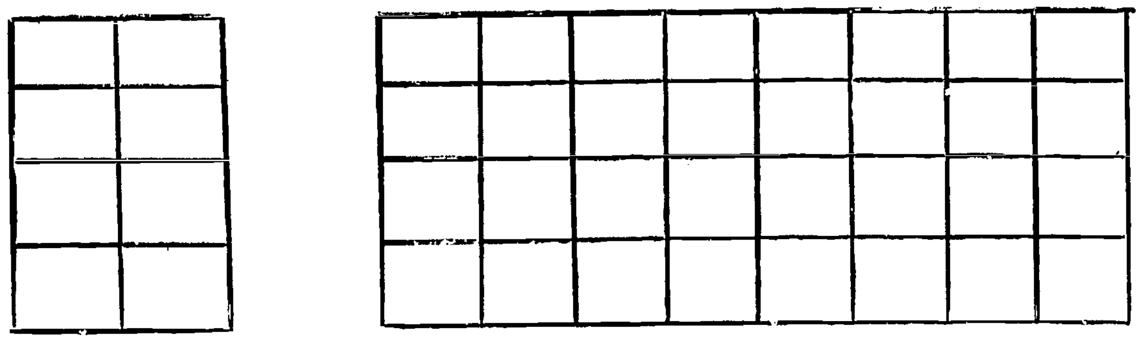


The children were asked to count the new arrangement. "Which pile has more? Neither. They both have four boxes. They both have the same number of boxes." The children were then asked to describe what happened.

"What happened? Did the pile get longer this way...Did the pile get longer this way?...What's the rule? When the pile gets longer this way, it gets shorter this way." In another variation of the task, the teacher asked the children to predict what would happen when the blocks were rearranged, telling them only about one of the dimensions. "And what's going to happen <u>this way</u>? Will it get longer or shorter?" When a child made a mistake, the teacher would act somewhat amused and remind the child of the rule, "Remember the rule: When it gets longer this way, it gets shorter this way."

6. <u>The dimensions compensate when liquid is mapped on a flat surface</u> (presented during sessions 2, 3, and 4). The purpose of this task is to create a transition between the fixed unit compensation rule as it applies to "boxes" and liquids. The analogy between boxes and liquids is based on the idea that a given amount of liquid is exhaustable. The children already knew that when there is so much liquid in a glass, one cannot drink forever. The amount is exhausted in a systematic fashion. The more one consumes, the less the amount remaining in the glass. The consumption of liquids, in other words, follows fixed-unit principles. The present task set simply demonstrated how the exhaustable characteristic of luquids can be "mapped" onto boxes. The teacher did not mention the relationship between consuming juice and the paint. He left his part of the equation to the children's intuition.

For the basic demonstration, he drew two piles of boxes on the chalkboard, one arrangement containing 8 boxes, the other containing 32. Both piles were the same height.

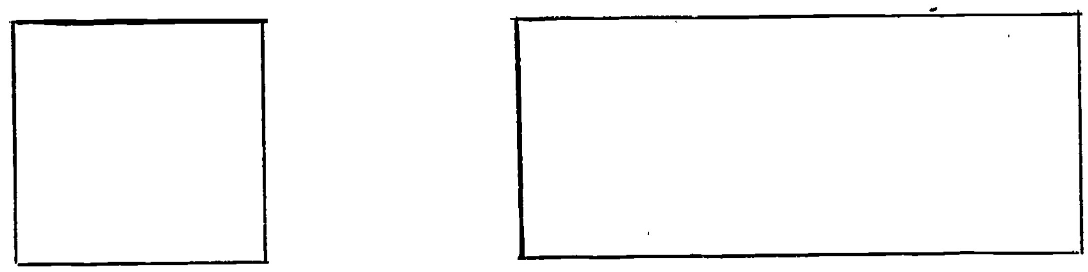


The teacher had the children note which pile was longer horizontally and vertically, which pile contained more boxes. He then chalked in all of the boxes on the left pile, starting from the bottom and swinging back and forth in horizontal strokes. "Pretend that I'm painting this pile of blocks. Look, how much paint I have to use. I have to use enough to paint how many boxes?...That's right, eight boxes. Now, how far would I be able to paint on this other pile, if I used just as much paint as I used over here? Well, ask yourselves, how many boxes did I paint here? So how many boxes can I paint here?...That's right, eight. Here I go..."

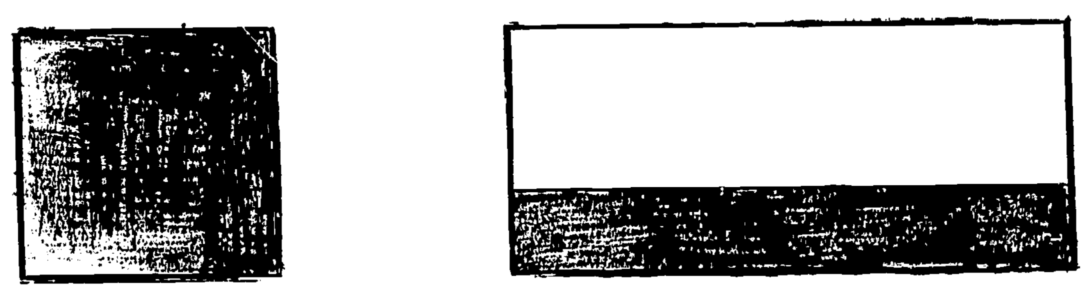
The teacher asked the question about size. "Which one of these painted parts is bigger?...Which one has more boxes in it?...Is one bigger than the other?...Well, why does this part look taller?...What's the rule: If it's longer this way, it's shorter this way...Sure, the same rule." The presentation corresponded closely to the box-piling presentation.

The teacher demonstrated the point correspondence of the painted boxes in the two piles. "Here's one way to see if the piles are the same. See if there's a box in this pile for every box in that pile. If there is, then they're the same." The teacher simultaneously touched the lower left box in each pile. "There's a box for this one." He moved to the next box. "There's a box for this one..." and so forth.

The basic demonstration was repeated with several different box arrangements. Then the teacher presented examples in which the interior squares were not drawn in. "Oh, we've really got to think now. Look at these boxes. I've got just enough paint to paint this (left) box."



"So here I go...Now, what if you have just as much paint as I used here and you want to paint this box. Would you be able to paint this whole box?...That's right, it's too big. So if you started at the bottom, and kept painting, you couldn't paint all the way up to the top. You'd run out of paint about here..."



"Does that look right?...Well, use the rule. What happened this way (width)? Is this (right) painted part longer this way or shorter?... Yes, longer. And if it gets longer this way, it has to do what?...It gets shorter this way (height). If it gets longer one way, it has to get shorter the other way. Say that with me..."

After the teacher demonstrated the procedure with several other no-interior-square examples, he introduced a construction task in which the children were allowed to "paint" the right rectangle. Most of the children had turns, and most could handle the variety of problems presented (all of which involved proceeding from a thin to a wide rectangle). One child "painted" the entire right rectangle. The teacher pointed out the contradiction. "Which of these boxes is bigger?...So which of them has more paint on it?...But you don't have more paint. You have just as much paint as I had when I painted this box. So you can't go all the way to the top." He asked the other children to tell the child the rule, "When it gets longer this way, it has to get shorter this way..."

After each child finished "painting" the right rectangle, the teacher asked him to describe the two painted parts. "Tell me about this part. Is it longer or shorter this way (height)? What about this way (width)? Tell me the whole thing. It's longer this way and shorter this way... Now tell me about the painted part you made. Yes, it's shorter this way, and longer this way." He concluded with a question about size. "Which painted part is the biggest?...That's right, they are the same. This one is longer this way, but it's shorter this way. The other one is shorter this way, but..."

Training Criterion

The criterion for the termination of instruction was the ability to handle a rectangle-tipping task and rectangle-painting task. The tasks were presented to the children individually during the fifth session. For the tipping task, the tester drew a rectangle (oriented either vertically or horizontally) on the chalkboard. She then asked the child to describe the rectangle (longer this way and shorter this way). Finally, she asked the child to describe the rectangle if it were tipped over (or standing up).

For the rectangle-painting task, the tester drew two rectangles on the chalkboard. She painted the rectangle with the smallest area (starting at the bottom). She then asked the child to show how the other rectangle would look if, starting at the bottom, he used the same amount of paint. If the child had trouble, she asked him to describe the painted part of the original rectangle and then apply the rule to figure out what his painted part would have to look like. All 15 experimental subjects successfully handled the problems (two subjects required about five minutes of additional tutoring). The training was therefore terminated at this time.

References

Bereiter, C. & Engelmann, S. Teaching disadvantaged children in the preschool. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966.

Brison, D. Acquisition of conservation of substance in a group situation. Unpublished doctoral dissertation, University of Illinois, 1964.

Bruner, Jerome S. The course of cognitive growth. American Psychologist. 1964, 19, 1-15.

Elkind, D. Children's discovery of the conservation of mass, weight, and volume. Piaget Replication Study II. Journal of Genetic Psychology. 1961, 98, 219-227.

Flavell, J. The developmental psychology of Jean Piaget. Princeton, New Jersey: Van Nostrand, 1963.

Inhelder, Barbel, Bonet, Magali, Sinclair, Hermine and Smock, C. D. On cognitive development. American Psychologist. 1966, 21, 160-164.

Lovell, K. A followup study of some aspects of the work of Piaget and Inhelder on the child's concept of space. British Journal of Educational Psychology. 1959, 29, 104-117.

Piaget, J. The origins of intelligence in children. New York: International Universities Press, 1952.

Piaget, J. The language and thought of the child. (Trans. by M. Gabain). New York: Harcourt, Brace, 1932.

Piaget, J. and Inhelder, Barbel. Le developpement des quantites physiques chez l' enfant. (2nd revised edition). Neuchâtel, Switzerland: Delachaux and Niestlé, 1962

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McCraw Hill, 1956.

Smedslund, J. The acquisition of conservation of substance and weight in children. I. Introduction. Scandinavian Journal of Psychology. 1961, 2, 11-20. (a)

Smedslund, J. The acquisition of conservation of substance and weight in children. II. External reinforcement of conservation of weight and of the operations of addition and subtraction. Scandinavian Journal of Psychology. 1961, 2, 71-84. (b)

Smedslund, J. The acquisition of conservation of substance and weight in children. III. Extinction of conservation of weight acquired 'normally' and by means of empirical controls on a balance scale. Scandinavian Journal of Psychology. 1961, 2, 85-87. (c)

Vinh-Bang. Evolution des conduites et apprentissage. in Morf, A., Smedslund, J., Vinh-Bang, and Wohlwill, J. F. L' appentissage des structures logiques. Etudes d épistémologie génétique. Volume 9. Paris, France: Presses Universities de France, 1959. pp. 3-13.