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AUTHOR	Lawton, Joseph T.; Redd,, P.
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ABSTRACT

Examined were effects of advance organizer (AO) instruction on acquisition of conservation concepts in 3- and 4-year-olds. Participants were 28 children who were equally divided into experimental and control groups, pretested, and found to be nonconservers. A sequence of two AO lessons and related learning activities was presented to the experimental group. Lessons focused on paying attention to special properties of objects and using high-order rules for solving conservation tasks. Control group children received regular instruction in a traditional preschool program. Posttests to measure immediate transfer of training and long-term retention of conservation concepts were conducted immediately after, and four weeks after, the training period. Results indicated that AO instruction was successful in promoting the learning of a high-order rule for conservation that children generalized to five conservation concepts. The high level of improved performance by experimental group children at posttest I was maintained at posttest II. Control group children showed little improvement in performance in both posttests, and their level of performance remained essentially preoperational. All children found number conservation easiest to deal with. Data suggested that the five conservation concepts were acquired in the following order: number, liquid quantity, length, area, and weight (mass). (RH)

EFFECTS OF HIGH-ORDER RULE INSTRUCTION ON PRESCHOOL CHILDREN'S UNDERSTANDING OF CONSERVATION

Lawton, J. T., and Reddy, P.

University of Wisconsin-Madison

Dr. Joseph T. Lawton
Department of Child and Family Studies
School of Family Resources and Consumer Sciences
University of Wisconsin
1430 Linden Drive
Madison, WI 53706
U.S.A.

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Abstract

This study examined the effects of advance organizer (AO) instruction on the acquisition of conservation, concepts in three- and four-year-old children. Twenty eight children participated in the experiment, with fourteen in each of the experimental (E) and control (C) groups. All children were pretested and determined to be nonconservers. A sequence of two advance organizer lessons on paying attention to special properties of objects and the use of high-order rules for solving conservation tasks along with related learning activities was presented to the experimental group. Control group children received regular instruction in a traditional preschool program not based on any particular theory of development or learning. In this program, children did have access to materials that might be used for discovering conservation concepts. Posttests were conducted immediately after the training period to measure immediate transfer of training, and after about four weeks to measure long-term retention of conservation concepts. Results indicated that AO instruction was successful in promoting the learning of a high-order rule for conservation that children generalized to five conservation concepts. The high level of improved performance by E group children at Posttest I was maintained at Posttest II. C group children showed little improvement in performance in posttests I and II and their level of performance remained essentially preoperational. All children found number conservation easiest to deal with. Apart from number conservation, performance by the E group on the remaining conservation tasks was closely comparable at posttest and delayed-posttest. However, there was some indication that acquisition of the five conservation concepts was in the order, number, liquid quantity, length, area, weight (mass).

EFFECTS OF HIGH ORDER RULE INSTRUCTION

ON PRESCHOOL CHILDREN'S UNDERSTANDING OF CONSERVATION

Introduction

This study examined the effectiveness of advance organizer instruction on preschool children's use of high-order rules for paying attention to special properties of objects and checking the results of transformations of objects on particular properties of these objects in connection with the learning of five conservation concepts; namely, number, weight (mass), area, liquid quantity, and length. Children who were in the experimental group received advance organizer instruction in accordance with Ausubel's theory of subsumption learning. Children in the control group attended a traditional type of preschool program in which they were encouraged to engage in exploratory, discovery learning. Learning materials were available, such as sand and water trays, counting games, and weighing games, that at least had the potential for the creation of transformations that might encourage the consideration of the conservation of particular properties of objects. Aside from this observation, the intention was to select a control group of children from a preschool program comparable in general quality to the experimental program.

Piaget's theory of conservation (e.g., Piaget, 1952) has been a central issue in research on children's cognitive development. Two of Piaget's collaborators, Inhelder and Sinclair, have said that the best indicator of a children's development of concrete operations is the ability to deal with conservation (1969, p.3) According to Piaget, children must understand reversibility by inversion (negation) and compensation (reciprocity) before they understand conservation. Bruner (1964) and Elkind (1967; Elkind & Schoenfeld, 1972) proposed that knowledge of the identity rule is also a necessary prerequisite for conservation. Bruner emphasized the rule of qualitative identity which refers to the child's understanding that, following some transformation of an object, the transformed object is still the "same object" as it was previously. Elkind's rule of quantitative identity refers to the child's understanding that, despite a transformation, the transformed object (s) is (are) still the same number, weight quantity, area, etc., as previously.

Reviewing research on the relationship between rule knowledge and conservation, Brainerd

(1978a, pp. 174-175) comments that, "A consistent finding has been that children understand (inversion) long before they can conserve the qualitative relationship between the standard and variable stimuli." Also, that there appears to be an invariant sequence in acquiring an understand ing of the four rules such that inversion is understood first, compensation and qualitative identity second, and quantitative identity third (Brainerd, 1977a, p. 175).

Research on the effectiveness of training children to use one or more of these rules has shown that children can benefit from instruction in the use of the compensation rule (e.g., Halford & Fullerton, 1970), the inversion rule (e.g., Beilin, 1971; Brainerd, 1973; Glaser & Resnick, 1972), and the identity rule (e.g., Siegler & Liebert, 1972; Hamel & Riksen, 1973; Field, 1981).

There has been considerable discussion on the most effective type of instruction in conserva tion concepts, and the age at which children are most likely to benefit from instruction. Learning experiments associated with Piaget's theory of development have been mainly in response to Pia get's claim that development always imposes constraints on children's learning. A major con straint is that, for example, children who are clearly preoperational cannot meaningfully learn con cepts that emerge at the subsequent stage of concrete operations. The two basic types of instruc tion used are tutorial and self-discovery. The latter approach has been promoted by Piaget and his co-workers who have stated that stage-related concepts such as conservation can be responsive to training on two conditions: that learning of a concept occurs only when it is understood by chil dren to some measurable extent, and if the training procedure resembles the kind of situation in which intellectual development occurs in everyday life. In other words, for understanding of a concept such as conservation to be meaningful, children must discover it for themselves as an out come of interactions with the environment. As children approach a logical understanding of the concept, guided-self-discovery instruction is expected to help the child to a final state of under standing (Piaget, 1970; Inhelder, 1972; Sinclair, 1973; Inhelder, Sinclair, & Bovet, 1974). The self-discovery approach requires children to predict a possible solution to a problem, test their pre diction through manipulation of objects in a way they consider helpful, and state their conclusions. At no time does the teacher directly teach a concept. Inhelder et al. (1974) investigated the efficacy of the self-discovery approach, but did not compare this method with a tutorial approach and less than half a dozen of the children in the study were younger than 5 years. Brainerd (1978b, pp. 91-93) compared two of the instruction experiments described by Inhelder et al. to similar experiments by Sheppard (1974), who used a tutorial approach to instruction. Children in the Inhelder et al. group had previously solved some conservation problems and were considered transitional between the preoperational and concrete operational stages of development. Children in Sheppard's experiment failed all initially presented problems and could be labelled as preoperational. Following instruction, of the children in the Inhelder et al. experiment, 21% made complete progress, 33% partial progress, and 46% no progress. Of the children in Sheppard's experiment. 40% made complete progress and the remainder, partial progress. Moreover, these learning effects generalized to conservation concepts of number, mass, length, and weight. There is other evidence from research, as mentioned below, that young children showing no initial ability to solve conservation problems can be successfully trained to do so.

Various training procedures have, in fact, been used to induce conservation in young children. Field (1987) has recently completed a meta-analysis of 25 conservation studies conducted through mid-1986. The studies are grouped according to Brainerd's (1979) three models of conservation training; namely, specific experience (SE) which provides direct exposure to particular instances of conservation, perceptual readiness (PR) where children are trained to pay attention to relevant cues (or properties of objects) and ignore irrelevant cues, and cognitive readiness (CR) where children are trained "in the nature of rules and strategies, such as addition/subtraction, identity, reversibility, and compensation" (Field, 1987, pp. 212-213). Some form of verbal rule instruction (VRI) is used in most of the various tutorial approaches. Field (1987, p. 239) mentions that, of the studies she surveyed, "VRI appears in 70% of the CR, 0% of the PR, and 50% of the SE". The most notable use of the guided-self-discovery approach has been by Genevans themselves. Compared to this approach, verbal rule instruction of one kind or another has usually proved to be more successful in inducing conservation (Beilin, 1965; Brainerd, 1974, 1977b; Carlson, 1967; Denny et al., 1977; Field, 1987; Gelman, 1969; Hamel & Riksen, 1973; Lawton, Hooper, Saunders &

Roth, 1984; Rosenthal & Zimmerman, 1972; Siegler, 1972; Siegler & Leibert, 1972; Sheppard, 1973, 1974; Sjoberg et al., 1970; Zimmerman & Lanaro, 1974; Zimmerman & Rosenthal, 1974). This present study would fall into both the PR and CR categories, as described by Brainerd and used by Field, because (a) children were instructed in paying attention to relevant attributes (properties), and (b) children were also instructed in verbal rules for identifying and attending to relevant attributes and in establishing quantitative identity.

Of particular interest to this study is the research of Gelman (1969), Field (1981), Lawton et al. (1984), and recent research by Lawton (1988). Gelman trained five-year-old children, estab lished as being non-conservers, quantity attributes related to number and length. The objective was to train the children to attend to relevant properties of objectives to establish sameness; same number, same length. This was accomplished through "oddity" training. At immediate posttesting the trained children showed significant improvement over their pretest performance on number and length conservation problems and performed well on liquid quantity and weight conservation tasks (non-specific transfer). This level of performance was maintained on delayed posttests three weeks later. However, it should be noted that these children tended to perform better on the con servation concepts associated with the training procedure (see Figure 1). Field (1981) trained pre schoolers to use identity, reversibility (inversion), or compensation rules. Identity training was found to be most useful and compensation not useful. Of the four-year-olds in her study, 55% and 53%, respectively, were successful on the conservation concepts of number and length immedi ately following training. Of these children, 23% and 35%, respectively, were also successful on the untrained quantities of mass and liquid. On a second posttest given 2-1/2 or 5 months later, these 4-year-olds had actually improved. Lawton (1988) and Lawton et al. (1984) have had success, using advance organizer instruction, in instructing preschool children in the use of general rules for paying attention to the properties of objects and establishing the conservation of a particular property of an object following a transformation. However, this instructional procedure was used for the learning of individual conservation concepts in a particular sequence. No attempt has previously been made to teach, by this method, the use of general rules for the solving of a class of conservation problems.

The advance organizer instruction procedure is based on Ausubel's subsumption learning the ory (Ausubel, Novak, & Hanesian, 1978). Superordinate concepts and high-order rules are pres ented first in the instructional sequence in what is called an "advance organizer" lesson. Being pro vided with a high-order rule for solving conservation problems in general, with the high-order rule being associated with the concepts of number, weight (mass), area, liquid quantity, and length, children are prepared "in advance" of particular instances of conservation problems (related learn ing activities) to which the single, high-order rule can be applied. Learning how to deal with par ticular instances of conservation is expected to "progressively differentiate" the general rule. It is predicted that the end result of this sequence of learning--advance organizer lesson followed by related learning activities--will be the meaningful learning and committing to long-term-memory of the high-order-rule for conservation, and the understanding that it can be generalized to a class of related concepts. It is expected that, if understanding and learning of the high-order rule and the five concepts mentioned above, has occurred, children will then apply the rule successfully to the solving of conservation problems in a class of problems containing those concepts.

Subjects

The participants in this study were 28 middle-class children of mixed ethnic origin, with 14 in each of two preschool programs. Program A was a formal structure preschool where the instruc tion process was based on Ausubel's theory of learning (the experimental program). Program B was a traditional community preschool where the program was not based on any particular theory (the control program). The mean chronological age of children was 4 years (range: 3 years, 1 month, to 4 years, 8 months) in Preschool A, and 3 years, 11 months (range: 3 years, 1 month, to 4 years, 8 months) in Preschool B. All children attended school five days per week.

Design

This study used a pretest-training-posttest-delayed-posttest design. Subjects in each preschool were pretested to initially determine who were conservers and nonconservers. The criteria for selection to the study was any child failing on each of the five conservation tasks. Instruction began immediately after pretesting, and lasted for one-and-one-half weeks. Posttests were conducted immediately following the training period and delay-posttests were administered four weeks following training to measure long-term retention of conservation concepts following instruction. All children were tested individually at each of three times of testing and the testing order of tasks was randomized across subjects. For each response following a transformation the child was asked to provide an explanation Examples of questions asked are given for a number of tasks and also examples of explanations following a correct justification.

The pretests and posttests consisted of a battery of co ervation tasks. The instructional materials consisted of a set of advance organizer lessons and related learning activities presenting general rules for and the special properties of the concepts of number, weight (mass), area, liquid quantity, and length for solving conservation problems. The instructional procedure is described in a following section.

Tests and Scoring Procedure

On the basis of Brainerd's (1977a) claim that there is an invariant sequence in the development of reversibility and identity rules for conservation, with quantitative identity appearing last, it was decided to focus instruction on the quantitative identity rule. Also, Field (1981) had most success inducing an understanding of conservation concepts with identity training, and Gelman's (1969) approach was essentially one of quantitative identity training. Therefore, the questions asked of children following a transformation in each conservation task referred to quantitative identity. A description of the battery of conservation tasks follows. Each task had two sub-tasks.

Conservation of Number

1. Pretest: This consisted of presenting two rows of six pennies in one-to-one correspondence. For sub-task 1, the first row of pennies was expanded in length, and the question was asked, "Does this row (pointing to the transformed row)" have as many (more or less) pennies as this row (pointing to the non-transformed row)?" In sub-task 2, one row of pennies was transformed into a heap and the question was asked, "Are there as many (more, or less) pennies here (pointing to the row) as there are here (pointing to the heap)?". Following a response, the

child was then asked,"How do you know that?" or "How could you tell?", or "Can you tell me why?"

2. Posttest: This consisted of presenting two rows of four flowers each in one-to-one correspondence. The first transformation (sub-task 1) was the expansion of one row of flowers. The second transformation (sub-task 2) involved piling one row of flowers on top of each other.

3. Delayed-Posttest: This consisted of presenting two rows of four beads each, in one-to-one correspondence. The first transformation was the expansion of one row of beads, and the second transformation consisted of heaping one row of beads.

Conservation of Mass

1. Pretest: This consisted of presenting two balls of playdough equal in mass, size, and weight. The first transformation was flattening one of the balls of playdough into a pancake. The second transformation was turning one ball of playdough into a hotdog. "Is this ball as heavy (heavier, or lighter) than this pancake (hotdog)?"

2. Posttest I: This consisted of presenting two face tissues equal in size, mass, and weight. The first transformation was folding one tissue in half. The second transformation was crumpling one tissue into a ball.

3. Posttest II: This consisted of presenting two pieces of cloth equal in size, mass, and weight. The first transformation was folding one piece of cloth in half. The second transformation was crumpling one piece of cloth into a ball.

Conservation of Area

1. Pretest: This consisted of presenting two identical green cardboard pieces equal in area and size (to represent fields), one toy cow on each field, six identical blocks for sub-task 1 and fourteen identical blocks for sub-task 2 (to represent barns). Three barns each were placed next to each other in the corresponding corners of the two fields. The first transformation consisted of scattering the barns on one field. Then all the barns were taken away and seven barns were placed next to each other in the corresponding corners of each field. The second transformation consisted of scattering all seven barns on one field. "Does this cow (in the field with barns next to each

other) have as much (more, or less) grass to eat as this cow (in the field with barns scattered)?"

2. Posttest I: This consisted of presenting two pieces of blue construction paper equal in area and shape (to represent ponds), six fish (for sub-task 1), and twelve fish (for sub-task 2). The first task consisted of placing three fish next to each other in corresponding corners of each pond. The first transformation consisted of scattering the fish in one pond. In the second task, six fish were placed in each pond in the same manner as above. The second transformation also consisted of scattering the fish in one pond. "Do these fish (all together in a corner of the pond) have the same (more, or less) space to swim in as these fish (scattered around their pond)?"

3. Posttest II: This consisted of presenting two pieces of tan construction paper equal in area and shape (to represent sand boxes), six shells (for sub-task 1), and twelve shells (for sub-task 2). Placements and transformations were identical to the ones above.

Conservation of Length

1. Pretest: This consisted of presenting two pieces of string (to represent roads) each measuring 15 inches in length, two toy cars, and one board measuring 20 x 20 inches. The two pieces of string were laid one inch apart, starting at the same edge of the board. The two cars were positioned at the starting points of the roads on the edge of the board. The first transformation was moving the road over by 4 inches. The second transformation was reshaping one road into a circle.

2. Posttest I: This consisted of two paper chains each 13 inches long. The two chains were laid next to each other starting at the same edge of the table. The first transformation consisted of curving one of the chains. The second transformation was reshaping one chain into a circle.

3. Posttest II: This consisted of two pipe cleaners equal in length (to represent roads), two clowns, and one board. The two pipe cleaners were laid parallel to each other on the board starting at the same edge of the board. The clowns were positioned at the very beginning of the two pipe cleaners. The first transformation consisted of moving the road by 4 inches. The second transformation consisted of bending one of the pipe cleaners into a circle.

Conservation of Quantity

1. Pretest: Two 400 ml. beakers filled with 100 ml. each of colored water. one 100 m. beaker (for sub-task 1), and one 1000 ml. beaker (for sub-task 2) were used. For the first transformation, the water from one 400 ml. beaker was poured into the 100 ml. beaker. The second transformation consisted of pouring the water from one 400 ml. beaker into the 100 ml. beaker.

2. Posttest I: Two 400 ml. beakers each filled with 100 ml. sand, one 100 ml. beaker (for sub-task 1), and one 1000 ml. beaker (for sub-task 2) were used. The transformations performed were the same as those under pretest above.

3. Posttest II: Two 400 ml. beakers each filled with 100 ml. birdseed, one 100 ml. beaker (for sub-task 1), and one 1000 ml. beaker (for sub-task 2) were used. Transformations performed were again the same as above.

Each correct conservation response, with a correct explanation, was scored 1. Since there were five conservation tasks, each consisting of two sub-tasks, the total possible score at each time of testing was 10. Children were tested individually in all problems. The testing order of the tasks was identical for each subject and the testing sessions were conducted with the tester and the child sitting at a table across from each other. Each session lasted about ten to fifteen minutes, and the order of presentation of transformations was randomized.

Teaching Materials

There were two advance organizer (AO) lessons. In the first AO, children were taught the general concepts of object, property, and special property. In the second AO they were taught a high-order rule for solving conservation problems within a specific class of conservation concepts comprising the concepts of number, length, quantity, weight (mass), and area.

Materials used in AO I were a chair, a jacket, three glasses, water, three pieces of rope, five pennies, four pencils, three blocks, four crayons, three pieces of paper, four pieces of string, and playdough.

Materials used in AO II were five blocks, playdough, three glasses, water, pieces of string, and pieces of paper.

Materials employed in the Related Activities (RAs) were a flannel board (to present stories), pictures, drawings, and cut-outs of an elephant, tiger, alligator, monkey, zoo-keeper, two boys, girl, woman, cookie dough, two witches, three beakers (two being of the same size), colored water, two pencils, pieces of paper.

Teaching Procedure

The training period lasted for one-and-a-half weeks and consisted of two advance organizers and a set of related activities. Each training session was conducted with small groups of three to five children, and each small group lasted for a period of fifteen to twenty minutes. Identical teaching methods were utilized and the groups received all the organizers and related activities. Instruction was provided by the second author. Both the AOs were conducted in question-answer type sessions and the teacher ensured that as far as possible, children were given a chance to answer questions, discuss changes, and manipulate materials. Answers to questions were provided only if the children could not supply the answer or responded incorrectly. The following is an editorialized, shortened example of AO1 followed by a similar example of AO2.

Advance Organizer

The teacher introduced the concepts "object", "property", and "special property".

Teacher: Let's look at all the different things in this room. Another word for "thing" is the word "object". Can you say that?

Child Object

Teacher: Good! There are many objects in this room Let's see if we can find some objects. Can you find a chair in the room?

Child (Find a chair).

Teacher: Is that chair an object?

Child: Yes.

Teacher: Let's see if we can find a jacket.

Child. (Find the jacket).

Teacher: Is that jacket an object?

Child: Yes.

Teacher. Let's see if we can find a glass.

Child. (Find a glass).

Teacher: Is this glass an object?

Child Yes.

Teacher: There are special things about every object and these special things are called properties. Can you say "property"?

Child Property.

Teacher: Good! Now let's take this jacket and look at it carefully. These are some of the special properties of this jacket: it has sleeves, it has pockets, it has a zipper, it has a hood. What other properties does it have?

Child: It is white.

Teacher: Good. It is white. That's a property the jacket has. Let us put away this jacket and look at this glass. What are some of the special properties of this beaker?

Child It is made out of glass. It will break if it is dropped. It is round. It's tall.

Teacher: OK, let's look at these three pieces of rope. Is a rope an object?

Child: Yes.

Teacher: Can you tell me some of the properties of the ropes?

Child: One is longer than the others. They are all white.

Teacher How do they feel?

Child: Rough.

Teacher. What can they be used for?

Child. To tie things up.

Teacher. So, objects have many different properties that we can look for

The remainder of the organizer was presented in the above fashion, with the teacher asking questions and helping the children respond. Questions also invited children to generalize the concept of object and property to objects that had properties of number, length, mass, quantity, and area. For example: Which glass has the most amount of water? Which glasses have the same amount of water? Which glass has the least amount of water? Let us look at one more special property. Let's look at area. Area means the amount of space you have. Can you look at these pieces of paper (five pieces of paper)? Some of them have the same amount of space on them don't they? Can you show me which pieces have the same amount of space? Which piece has more paper? Which piece has less paper?

Advance Organizer II

The subjects were reminded about the important aspects of advance organizer I--Objects, properties, and special properties. Then the teacher proceeded:

> *Do you remember the last time you were here? We talked about looking at one special property of an object or objects. Sometimes when the special property of an object is not changed, other properties of the object are changed. Here is an example. Let us look at this group of blocks here. What are the properties of these blocks? There are five blocks, they are square, they are hard, they are all red, they are laying side-by-side. This group of blocks has many properties. Now let us look at one special property; let's look at number. How many blocks are there? Five. What special property did we look at? Number. We looked at how many blocks there are. We counted five. Now let us put the blocks one on top of the other. They look different don't they? They are now standing one on top of the other. Even though they look different, has the number of blocks changed? How many blocks do we have? Five. How do you know that we still have five? We counted. OK, now what if I added one block to this group of blocks? Do we still have five? No. How many blocks do we have now? (counting). OK. Six. Now, what if I took away one block from the five blocks. how many would I have? Four. So the special property we are looking at changed when we added something to or took away something from the special property, number. When we change the shape of the five blocks, how can the special property--number--stay the same? Don't add any blocks. And? Don't take away a block Good!*

The remainder of the organizer was presented in the above fashion, with the teacher asking questions and helping the children answer. Each of the five conservation concepts was treated in this fashion. It is important to add here that (1) none of the materials used in the test battery were included in these instruction sequences, (2) the children were never asked to solve an actual conservation problem (3) if children at first failed to answer a question, the teacher provided a correct response, repeated the question, and then asked a similar question. At the end of each section of the AO, and in conclusion, the teacher summarized the procedure (rules) for identifying relevant properties and for making comparisons following a change in an object. It was also emphasized that these procedures could be used in a similar fashion for each of the examples.

Related Activities

The following is an example of one related activity during which children had the opportunity to apply the concept "special property" and the rule to find out whether a property has changed; then check to see if anything has been added to or taken away from the special property.

Teacher: *Do you remember the last time you were here? We talked about looking at one special property of an object. We also talked about a rule that we can use to tell whether a special property has been changed or not. Let's see if we can remember the rule. Now I have some stories to tell you.*

A flannel board and the cut-outs were used as illustrations. The stories were accompanied by appropriate actions.

Teacher. *Here is a zoo and here is a zoo-keeper. One day, four new animals joined the zoo. Here they are. (Put out elephant, tiger, alligator, and monkey.) The zookeeper lined up all the animals, told them to stay where they were, and said that he would find their cages and then come back to get them. He said to himself, "I have four animals here (count with children) all in a row." As soon as he left, the animals decided to run away in all different directions. When the zookeeper came back, he took one look and said, "Oh no! The animals have run all over the place." He had to go and find them and bring them back again. He said to himself, "Do I still have four of them?" Please tell me (to children), how can we tell if the zookeeper still had all the animals back again?*

Children count and answer. The story is presented twice again. The first time one animal is "lost", and the second time an animal is added to the group. In both cases, the zookeeper asks children to solve his problem.

Teacher: *Tom and Susie are brother and sister. One day their mother gave them the same amount of cookie dough each to play with. As soon as mom left, Tom decided he was going to tease Susie. He made her dough into a ball and his dough into a bog, flat, pancake. He told her that he had more dough than she. That is exactly what Susie thought. What do you think?*

To reiterate, the objective of the AO and RA lessons sequence was: (1) to instruct children in the concept of special property and how to locate and pay attention to a special property in an object (or set of objects), especially when the object (or set of objects) was changed in some way (transformation), (2) to make comparisons of an object pre and post transformation with reference to a special property, and (3) to use the rule of checking whether or not during the transformation anything had been added to or taken from the special property.

Teacher: *When an object (or set of objects) is changed in some way, and--when we*

*are paying attention to a special property of that object (or set of objects)--
To find out if the special property has also changed, then--CHECK TO SEE
IF ANYTHING HAS BEEN ADDED TO, OR TAKEN AWAY FROM
THAT SPECIAL PROPERTY. If nothing has been added to or taken away
from that special property, then--THE SPECIAL PROPERTY HAS
STAYED THE SAME.*

Results

Posttests and delayed-posttest means and standard deviations for both groups are presented in Table 1 (attached). Preliminary t-test analyses indicated that there were no sex differences for both treatment groups at posttest and delayed-posttest.

Insert Table 1 about here

A condition (2) x task (5) x time of testing (3) repeated measures analysis of variance was performed on the posttest data. The only main effect attaining significance was for between-group performance ($F = 13.01$, $df = 26$, $p<.05$). There were no interaction effects for time or tasks, suggesting that (1) the significant differences in performance between E and C groups at posttest was maintained four weeks later at delayed-posttest; (2) each treatment group scores across tasks at posttest and delayed-posttest were in close correspondence, being high for the E group and low for the C group.

Post hoc t-test analyses indicated significant between-groups differences in performance at posttest ($t = 3.96$, $df = 26$, $p<.05$) and at delayed-posttest ($t = 2.89$, $df = 26$, $p<.05$). T-test analyses between-ages and within groups were also performed. The results showed no significant differences between (a) control three- and four-year-old children at both posttest and delayed-posttest, or between (b) experimental three- and four-year-olds at both posttest and delayed-posttest.

The results of between-ages and between-groups analysis showed (a) no significant differences between control and experimental three-year-olds at posttest, but a significant difference at delayed-posttest ($t = 2.37$, $df = 11$, $p<.05$); and (b) a significant difference between control and experimental four-year-olds at posttest ($t = 4.38$, $df = 13$, $p<.05$) and at delayed-posttest ($t = 2.78$, $df = 13$, $p<.05$). In all cases, differences favored the E group children.

Pearson product moment correlations between posttest and delayed-posttest mean scores on all tasks indicated that, for both E and C groups, performance at post- and delayed-posttests was very similar on all tasks, being high for E group children and low for C group children. It should be mentioned here that, on the basis of prior research, we would expect to find horizontal decalages in conservation concept development. For example, children usually conserve number before quantity (e.g., Brainerd & Brainerd, 1972; Gruen & Vore, 1972), and quantity before weight before volume (e.g., Chittenden, 1964; Uzgiris, 1964). Also, children's performance on conservation tasks usually improves with age (e.g., Field, 1981; Gelman, 1982). Field (1987, p. 246) suggests there is little evidence that 3-year-olds are able to really understand conservation concepts, though the status of 3-year-olds deserves further study. The lack of task main effects and condition x task interaction, and the lack of clear-cut age effects, is probably due to the lack of statistical power on account of the small sample. However, the data do indicate that, compared to other conservation concepts, at both post- and delayed-posttests, performance on number conservation tasks was somewhat more advanced in the case of both treatment groups. In fact, the data suggest that, for both post- and delayed-posttests the order of acquisition of conservation concepts, ignoring length and area, was number --> quantity --> weight, which supports the results of previous research.

The data were also examined for the percentage of children passing each task at two times of testing (see Table 2 attached). The criterion for passing a task was success on both subtasks for each conservation concept. Data in Table 2 show that a much greater percentage of E group children passed the five conservation tasks at both posttest and delayed-posttest. The experimental group children maintained the improved level of performance at initial posttesting four weeks later. The fact that, of children in the control group, at posttest 32%, 14%, and 10%, respectively, passed the number, area, and length tasks is difficult to explain. This success was repeated at delayed posttest for number, but success at area and length had disappeared.

Insert Table 2 about here

It is worth mentioning here the types of explanations children offered related to successful judgments on the five conservation tasks. The following examples are taken from the post- and delayed-posttests. They serve to illustrate that children used both (reversibility) inversion (I) and quantitative identity (QI) to explain the conservation of a quantity property following a transformation. However, it must be added that a quantitative identity rule was most often used.

Number:

1. Following the expansion of one row of two rows of four flowers: *"They're the same. See* (counting 4 in both rows), *you didn't add any more flowers and you didn't take any away* (pointing to the expanded row)." **QI**

2. Following the expansion of one row of two rows of four beads: *"They're the same. You made it far away from each other. Put it back in the row like it was. Then it'll be the same."* **I**

3. *"The same 'cause, no matter how you move it, it's still the same number. You made this row a little longer. Put it back. See, the same. And you can count it--see, four here and four here."* **QI & I**

Length:

1. Following the transformation into a circle of one of two strings of equal length: *"Same length. They're the same. 'Cause, you made that into a circle and that into a line. But they're the same length, 'cause, this one, you didn't add any more string, and you didn't cut any away."*

2. *"They're the same. 'Cause, if you stretch it* (the circle of string) *it's the same. You just twisted it. But we measured them."* **I**

3. *"You just turned that into a circle. You didn't put any string on, and you didn't cut off."* **QI**

Weight:

1. Following the transformation into a sausage one of two equal weight balls of playdough: *"They weigh the same. Even though it's a sausage it weighs the same. If you eat some, then it won't."* **QI**

2. *"It's a pancake, but it's the same.* (How is it the same?) *It weighs the same as that. Roll it into a ball again. You didn't put more in or take any away. It'll be the same."* **I & QI**

3. *"You just crumpled it* (piece of tissue paper). *Spread it out. It's the same."* **I**

Liquid

1. *"It's the same, because the water didn't run away, and you didn't*

Quantity: *make any come in."* **QI**

2. *"Same, 'cause you used the same sand. There's no more. And you didn't throw any away."* **QI**

3. *"Just as much birdseed. You didn't throw any away. Pour it back. It's as much."* **I**

Area:

1. Following the scattering of shells on one of two representational sandboxes of equal area: *"The same sand to play in. 'Cause you just did this* (showing how the shells were scattered). *Put them back. It'll be the same."* **I**

2. *"The fishes have the same space. Only if you dig the pond bigger, or make it smaller, it will change."* **QI**

3. *"The same, 'cause we made the sandboxes the same size. You can put lots of toys in this, but they're the same size."* **QI**

Discussion

The results of this study show that the AO + RA sequence of instruction was very successful in inducing in preschool children (1) an understanding of "special property", (2) an ability to isolate and pay attention to a special property in an object, or set of objects, with multiple properties, (3) an ability to observe the transformation of an object, or set of objects, and at the same time pay attention to the identified special property of that object, or set of objects, (4) an ability to listen to a question asking whether, following a transformation, a special property had also been changed, and know how to apply the higher-order rule of finding out whether the special property had changed or not by checking if anything had been added to, or taken away from that special property. If successful in this complete procedure, the child could respond that the special property had remained the same.

Success in training preschool children to attend to the crucial, special property to be observed in any conservation task, and ignore irrelevant properties lends support to the results of the studies by Gelman (1969) and Field (1981). Gelman suggested that young children fail to pass conservation tasks because they tend to pay attention to irrelevant properties and changes. In Gelman's study, children were highly successful in solving conservation problems for which they had been trained to attend to relevant properties--namely, number and length. Field (1987) also mentions the relevance of the attentional theory of Zeaman and House (1963) for this approach to training. They suggest that, once children pay attention to the relevant dimensions of a task, learning proceeds very quickly. Field points out that the theory is applicable to the complexities of learning conservation concepts. Training children to pay attention to, to focus on relevant attributes of objects does, in itself, influence young children's acquisition of conservation. Children's success on conservation tasks, as reported by Gelman (1969), indicated by percentage of correct scores, at pretest and delayed posttest for these tasks, and the non-specific transfer tasks of liquid and weight (mass) are shown in Figure 1, and are compared to the results from this present study. It is clear that the 4-year-olds of this present study were equally as successful as the 5-year-olds in Gelman's study. And it can be added that verbal rule instruction in the content of a variety of materials and examples of transformations of objects, coupled with a high order qualitative identity rule, resulted in successful generalization to five conservation concepts.

Insert Figure 1 about here

Field concludes from her review of preschool conservation training studies that an investigator's theoretical stance has consequences for both the design of a study and interpretation of results (1987, p. 210). I have already mentioned that this present study contains aspects of both perceptual and cognitive readiness models. Also, a very different method of instruction was used from the more traditional VRI training approach, where the assumption is usually made that learning will be incremental. Implicit in the method of instruction used in this study was the objective of improving children's ability to generalize by teaching them, in the first instance, general rules for solving problems of conservation. With respect to interpreting results, Field suggests that a child should be scored a conserver of any conservation concept only if all prefe[illegible]ed judgments and explanations were conserving responses. She goes on to say that, "this system provides more information than the sum of responses can." (Field, 1987, p. 244); the latter scoring procedure being that usually adopted by researchers who expect conservatio[illegible]e merely a matter of continuous, incremental learning. I support Field's contention, that such scoring criteria provide more information but not that complete success means, necessarily, that a young child can be considered a "conserver", at least in a strictly Piagetian sense. The percentages of children passing all five conservation tasks is interpreted as a measure of the efficacy of the AO instruction method used to improve transfer of training, to improve generalization. Field claims that aspects of methodology, such as number of training sessions and number of concepts trained reflect investigators' notions of how children learn while other aspects, such as adequate justifications, testing for generalization, and delayed posttesting indicate the influence of Piaget (Field, 1987, p. 246). This study included all these aspects, but not for the reasons mentioned by Field. We believe that generalization from learning will always be relatively limited. There is no expectation that the conservers of this study have come to master conservation in general, no matter what the context or circumstances. We believe that there will always likely be some restriction on the extent of transfer of training because of the effect on children's performance of the changing context and complexity of various conservation problems. Any discussion on generalization, or transfer of training, should include reference to the Piagetian concept of "structures-of-the-whole" (structures d'ensemble, e.g., Piaget, 1942). There is not room here to include mention of this important Piagetian concept (for interested readers, see, for example. Bingham-Newman & Hooper, 1974, 1975, and Brainerd, 1975a, and b). Suffice it to say that, from the standpoint of Ausubel's theory of subsumption learning (Ausubel, Novak, & Hanesian, 1978), the generality of concepts, and rules, will always have some limit. For young children the extent of an understanding of a general concept can be expected to be less than that for older more experience children (e.g., Lawton, 1988). All the requirements of instruction and testing reflect the underlying principles of subsumption learning; essentially that AO instruction has the potential for inducing long-term remembering of general concepts and rules. Therefore, generalization to related sub-concepts and rules is expected, though the extent of generalization will be limited.

In this study, generalization was tested only in the context and limitation of five particular conservation concepts. It remains to be seen whether a general rule, taught within the context of a particular partial class of problems might possibly generalize to other similar problems in that class.

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Table 1

Means and SD's for each of Five Conservation Tasks at Post- and Delayed-Posttesting.

		E Group (N=14)		C Group (N=14)	
Time of Testing		Mean	SD	Mean	SD
	Number	1.79 *	0.58	1.14	0.86
	Leng	0.93	1.00	0.00	0.00
Posttest	Quantity	1.29	0.99	0.00	0.00
	Weight (mass)	0.93	0.92	0.14	0.36
	Area	0.93	0.87	0.09	0.73
	Number	1.17	0.73	1.43	0.94
	Length	1.21	1.04	0.21	0.58
Delayed	Quantity	1.17	0.92	0.14	0.53
Posttest	Weight (mass)	1.10	1.04	0.21	0.58
	Area	1.14	1.03	0.14	0.53

* Score range for each task: 0-2.

Table 2

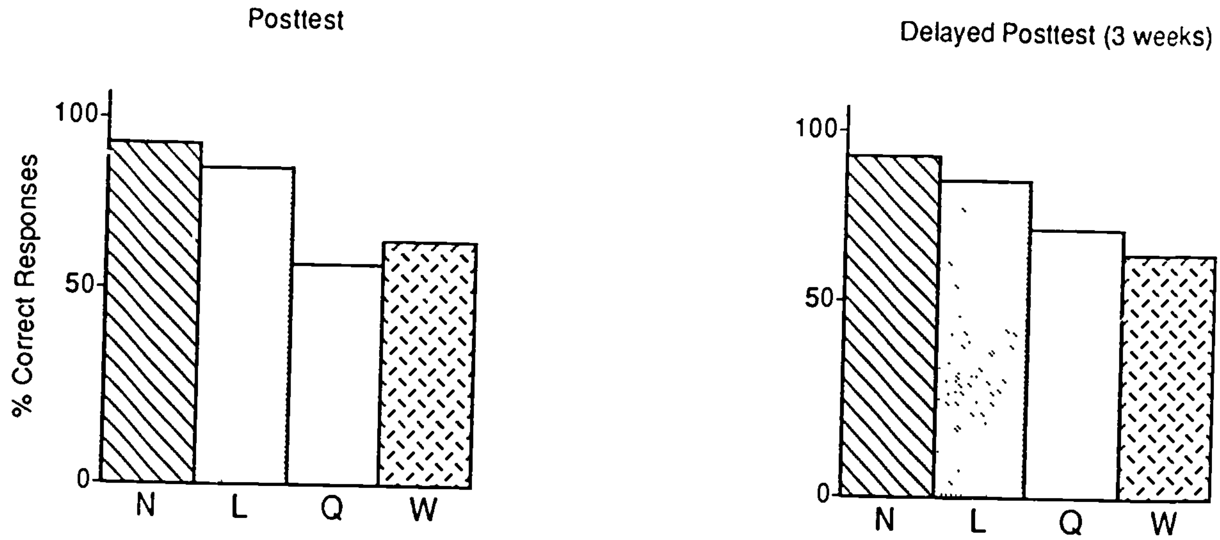
Percentage of Children Passing Each of Five Conservation Tasks at Post- and Delayed-Posttesting

Task	E Group Posttest	E Group Delayed Posttest	C Group Posttest	C Group Delayed Posttest
Number	84	84	32	37
Length	47	49	10	0
Quantity	63	58	0	0
Weight (mass)	37	42	0	0
Area	48	56	14	0

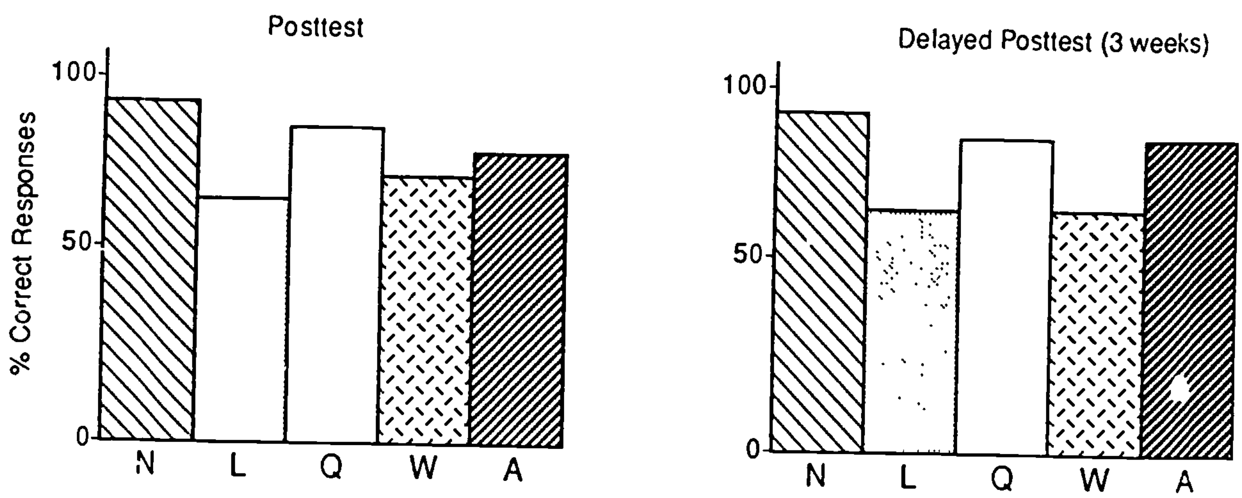
Criterion for passing each task was a score of 2 out of 2.

Figure 1

Comparison of Results from Gelman's Study and Present Study



Results of Gelman's Training Method (1969)



Results of Present Study (1987)

N = Number
L = Length
Q = Quantity
W = Weight (mass)
A = Area