

INDUCING LIQUID CONSERVATION

IN CHILDREN USING

A MODIFIED HALFORD LEARNING
THEORY MODEL

BY

MICHAEL ZROBACK

SUPERVISORS:

DR. L.M. ANDERSON

DR. P. GUPTA

Most pieces of work are the end products of a long and arduous process of collective struggling. In the struggle to complete this particular study, I was fortunate enough to be aided by an unusually talented and persistent group of people. Each contributed in his own way according to his individual talents, whether by encouragement, advice or by giving of himself. Those to be thanked for their help in particular include Janis, Larry, Prem, Vi and Linda. Without their help, this project would never have been completed.

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ABSTRACT

Contingent upon their ability to perform a conservation of liquid substance test, two groups of Ss were selected for experimental treatment: 20 natural conservers (NtC), and 40 non-conservers (N-C). The N-C were randomly divided into two equal groups - an experimental group and a control group. The experimental group was taught conservation of liquid by a learning program based upon Halford's learning theory model of liquid conservation. At intervals of 24 and 6 days after training of the N-C, all the Ss were given a conservation of liquid test. The Ss were also asked their reasons for thinking that the amounts of water were equal or different after each change of shape was performed. In order to determine their resistance to extinction, both natural conservers and those non-conservers who had learned to conserve were given 6 extinction trials.

A chi square analysis on the post test data showed that the treatment group was significantly more successful than the control group ($P < .001$). This experimental group was not, however, as successful as the NtC's after comparisons at 24 hours ($P < .05$) and 6 day intervals, implying that method of acquisition and performance were related. An analysis of the Ss explanations revealed that conservers generally based their judgements on elementary logic. Results also showed that both the NtC and the N-C who learned to conserve were highly resistant to extinction.

INTRODUCTION

Of the several attempts to account for the development of a child's intellect, perhaps the best known is that of Jean Piaget (1952). However, few North American psychologists have felt comfortable with Piaget's concepts because he did not perform numerous extensive studies to substantiate his ideas in detail. Instead, Piaget preferred to work with a few subjects in great depth. In this way, he was able to map out his account of the intellectual development of the child, leaving others to perform the studies filling in the finer details and testing the finer implications of his developmental theory.

One of Piaget's concepts that has received considerable attention is the notion of invariance; i.e., how does a child learn that a change in appearance does not necessarily signify a change in amount, weight, number, area, etc? Some researchers, eg. Halford (1970), Gagne (1968) have not been satisfied with Piaget's account of how the concept of liquid invariance, in particular, is learned; consequently, they have developed their own models to account for the acquisition of liquid conservation.

G.S. Halford (1970) has developed a learning theory model that accounts for the acquisition of liquid conservation. This model concerns itself with the learning of liquid conservation "naturally", i.e., the model concentrates on the processes involved in learning conservation that occur in the course of the child's daily life.

Since he is concerned with how a child acquires conservation naturally, Halford uses indirect methods to teach this concept. It is apparent, however, that much of the learning that takes place in children in school, etc., results from direct teaching methods; i.e., children are taught in a very direct manner by teachers, parents and peers.

Given this line of reasoning, the concern then becomes one of determining whether or not the application of a particular model of learning, utilizing direct teaching methods, can influence a specific aspect of childrens' intellectual development. More specifically, in terms of the present study, the concern becomes one of determining whether or not the application of Halford's learning theory model, modified by the inclusion of direct teaching methods, is capable of inducing liquid conservation in children. It is the focus on making the teaching methods direct and explicit that distinguishes this present extension of Halford's study from a mere replication.

The purposes of the present study are:

1. To determine whether or not a modified version of Halford's learning theory can be used to successfully induce conservation of continuous quantity directly.
2. To determine the resistance to extinction of conservation of continuous quantity acquired in this way.
3. To determine whether or not there is a difference in the level of sophistication among the control Ss, the experimental Ss and the natural conservers in the acquisition of the concept of conservation of continuous quantity; i.e., is there a difference in the level of the conservation concepts: a) relating to the method of acquisition (acquired vs. natural), b) as shown by the verbal reasons given for the choice of container after each transformation.

CHAPTER I

OVERVIEW OF PIAGET'S CONCEPTS OF INTELLECTUAL DEVELOPMENT

Piaget defined intelligence as "...a particular instance of biological adaptation" (Piaget, 1950) and as "...the form of equilibrium toward which all the cognitive structures tend," (Piaget, 1952). Thus, intelligence is seen by Piaget as a biological achievement that allows the individual to interact with the environment on a psychological level. He also stresses the harmonious interaction between the environment and the individual's cognitive structures. The biological adaptation to which he refers occurs as a result of two basic tendencies that all organisms exhibit: organization and adaptation.

In its interactions with the environment, the organism organizes its processes (physical and psychological) into coherent systems. Lower structures of behaviour are continually being organized into higher order structures. For example, a child may notice that the amount of liquid in a container varies with a change in the length of the container, the other dimensions remaining constant. He may also notice that the amount of liquid in a container changes with its width, the other dimensions being equal. When faced with a situation in which a liquid is poured from a long, narrow container into a short, wide one, he may be unable to predict invariance in the amount of liquid. This failure in prediction shows that he has not effectively combined the two cognitive structures.

In combining these two separate structures into one higher order structure (called by Piaget compensatory relations), the child grasps the concept of invariance of quantity. This higher order structure is qualitatively different from the lower order structures that combined to produce it.

The second tendency that all organisms inherit is called adaptation (Piaget 1950). This tendency is composed of two complementary processes called assimilation and accommodation. In assimilation, the organism incorporates and utilizes stimuli from the environment, while in accommodation, the stimuli cause the already existing structures within the organism to be modified. On the one hand, the organism assimilates features of the environment into its psychological structures, while on the other, it modifies its structures in response to the pressures of the environment. As a result of the interaction of these reciprocal processes, the organism adapts to its environment by forming a progressive series of psychological structures that differ qualitatively from one another throughout the organism's life time. The present research focuses on processes which occur during the transition from a preoperational to a concrete operational stage.

The stage of concrete operations lasts from approximately seven years of age until about eleven or twelve years of age and is characterized by the emergence of kinetic symbolic activity (Piaget 1969); i.e., the child is now able to symbolize motion

and processes as opposed to static states. It is this kinetic aspect of symbolic activity that makes the concrete operational stage qualitatively different from the preoperational stage. By active adaptation to the environment, the child discovers new structures and at the same time is organizing them at successively higher levels.

When the child's discovery of such processes as compensation, identity and reversibility frees him from his perceptions, he has entered the period of concrete thought, while in the preoperational period of thought, the child's concepts were bound primarily by his perceptions.

A child, during the preoperational period of intellectual development, concentrates on static states while at the concrete operational period he concentrates on transformations. These transformations (compensation, identity, and reversibility) allow the child to use elementary logic and reasoning to understand the world. His thinking, however, is still bound to concrete objects.

Piaget's Notion of Conservation of Liquid Substance

According to Piaget (1950) the ability to conserve earmarks the child's transition from the period of pre-conceptual thought to the period of concrete operational thought. In order to conserve the child must be able to free his concepts from his perceptions and use elementary logic and reasoning to understand

the world. Intellectually, the child interacts with the world through his cognitive structures, and the transition to the concrete operational period is marked by the development of new structures. In the case of quantity, these new structures are compensatory relations, identity and reversibility.

The term compensatory relations refers to the child's ability to recognize that a change in one dimension can be compensated for by a change in another dimension. Identity refers to the cognition that the amount of substance remains invariant despite transformations in the material; i.e., nothing has been added or subtracted - it is the same material. Reversibility refers to the ability to recognize that the transformed material can be retraced, the actions cancelled and the original state restored. As a result of developing and using these processes, Piaget believes that a person's thought processes go through a qualitative change, allowing him for the first time to use logic and reasoning. A major problem with this paradigm (action-equilibrium hypothesis) is that it does not provide much concrete evidence regarding the conditions necessary for the transition between periods (Piaget, 1950); (Flavel, 1950).

Equilibrium is a dynamic balance between a person (his cognitive structures) and the environment. The child is always active, trying to understand and interpret the environment, attempting always to structure it. The person's intellectual system is always approaching a dynamic equilibrium. This is

a state in which the cognitive system neither needs to distort events to assimilate them, nor needs to change much to accommodate these events. When a person's intellect is developing, it is often thrown into disequilibrium when the information it has gathered does not fit into its already existing structures. Consequently, the child must rapidly modify them in order to be able to effectively interpret this new information. A person's cognitive system is thrown into disequilibrium at the beginning of each successive stage of intellectual development because he has perceptions that he cannot explain. Only when he has assimilated the new information and accommodated his previously existing structures do these perceptions have meaning for him. Thus, he has gone from equilibrium to disequilibrium to a higher level of equilibrium.

General Method of Inducing the Concept of Conservation

It seems to follow from the "action-equilibrium" hypothesis that in order to accelerate a person from Period to Period, one must induce a state of disequilibrium within the child. Secondly, he must be helped to discover structures that will enable him to interpret the new information which has caused the disequilibrium. He can then achieve a higher level of equilibrium. Following this line of reasoning, researchers have tried to accelerate subjects from the preoperational thought period to the period of concrete operations. One area of research has dealt with conservation of continuous quantity (Brisson, 1966; Brisson & Bereiter,

1967; Engelman, 1967; Goldschmid, 1968; Inhelder et al, 1966; Lefrancois, 1968; Rattan, 1970; Sigel et al, 1966; Sullivan, 1966; Waghorn & Sullivan, 1970). A common aspect of the above research was that they first caused a disequilibrium in their subjects by having them assimilate new information which they could not interpret effectively. It was found that one effective method of instilling disequilibrium in subjects was to pour liquid from a standard container into a comparison container of different dimensions. The subjects were asked to judge whether or not the amount of liquid in the comparison container was more, less, or equal to that in the standard container. Equilibrium on a higher level was arrived at by helping the subjects to accommodate to the new information by aiding them in developing the new structures of compensatory relations, identity and reversibility.

Role of Age in the Acquisition of Conservation of Liquid Substance

It is critical to Piaget's theory that the development of the intellect involves qualitatively different stages. His clinical method of experimenting, however, has not led to the establishment of age norms for these stages. Instead he was able to conclude that the child's thought processes changed from preoperational to concrete operational anywhere from seven to ten years of age. This finding is substantiated by Elkind (1961) who found that 75% of the subjects who were able to conserve quantity were eight years old. However, the quantity Elkind refers to is

solid quantity, not continuous quantity. In an earlier study (Elkind, 1961b) found continuous quantity more difficult to conserve than solid quantity, even for subjects six and seven years old. A study by Goldschmid (1967) confirmed that continuous quantity is more difficult to conserve than is solid quantity. The subjects used in studies of conservation of continuous quantity varied in age from five years of age (Sigel et al, 1966b) to 6½ to 8½ years of age (Waghorn & Sullivan, 1970). However, the young subjects in Sigel et al (1966) study had I.Q.'s in the 150 range and M.A.'s of 7½ years. Consequently, they were able to function as well as the relatively old subjects of Waghorn and Sullivan (1970). In studying the acquisition of the conservation of continuous quantity, it would seem, therefore, that the Ss should probably vary from seven to eight years of age.

Role of Intelligence in Learning to Conserve Liquid Substance

In the discussion of the transition between the various periods in the intellectual development of the child, Piaget does not mention the effect of intelligence as measured by traditional I.Q. tests on this transition. In a study by Waghorn and Sullivan (1970) intelligence was considered to be quite an important variable because they found that their two experimental conservation groups had higher I.Q. scores on the S.R.A. Test of Primary Abilities than did their non-conservation group.

Others (Elkind, 1961b, Goldschmid, 1967) placed somewhat less importance on the relationship of "traditional" intelligence

and ability to conserve as a result of their finding that the correlation between conservation of quantity and I.Q. scores was positive but low. Elkind correlated scores on conservation of quantity with WISC scores and found that the verbal scale and full scale correlations (0.47 + 0.43) were significant. Goldschmid (1967) correlated scores on post tests of conservation of continuous quantity with Ss M.A., and scores on the full scale WISC and WISC vocabulary sub-tests. He concluded that the factors of I.Q. and vocabulary may differentiate children of equal age with respect to their performance on conservation tasks.

Brisson and Bereiter (1967) placed the least emphasis of any of the researchers upon the relationship of I.Q. and conservation ability. Their study led to the conclusion that amount of training needed for conservation was not related to I.Q. According to their study, traditional I.Q. was important only in extinction because retarded conservers extinguished much more quickly than normally intelligent conservers.

The conclusion from the above studies seems to be that intelligence relates positively to the acquisition of conservation. Consequently, in a study in which subjects are attempting to learn conservation of continuous quantity, they should be of at least normal intelligence, and experimental and control groups should not differ significantly with respect to intelligence.

The Role of Manipulation of Apparatus and Verbal Instructions
in Teaching Conservation of Liquid Substance

If one examines the methods of teaching in the studies where conservation of continuous quantity has been successfully induced in subjects, it is apparent that these methods vary greatly with respect to two variables: the amount of manipulation of apparatus on the part of the subject and the effect of verbal instructions on the subject's learning. Also, the subjects in these studies acquired conservation by learning either all or a combination of the three processes of compensatory relations, identity and reversibility. Consequently, any discussion concerning the methodology of teaching conservation should centre on the extent to which the subjects manipulate the apparatus or watch it manipulated by the experimenter, and the effect that verbal instructions have on the subject's learning.

A study by Rattan (1971) attempted to clarify the roles of manipulation, demonstration and language (verbal instructions) in the acquisition, retention and transfer of two-dimensional space, number, substance, continuous and discontinuous quantity, weight, length and area conservation. He used four experimental groups, one for each of the following experimental conditions: high verbal demonstration (Ss given verbal rules and were able to watch experimenter manipulate objects), low verbal demonstration (Ss were not given rules and were allowed to watch experimenter perform the transformations), high verbal manipulation

(Ss given verbal rules and were allowed to manipulate the objects) and a low verbal manipulation group (Ss were given no verbal rules and were not allowed to manipulate the objects).

His results showed that there was no significant difference between the manipulation and demonstration conditions, seeming to indicate that it does not really matter whether the subject performs the transformations or whether he observes the experimenter transforming the objects. Data also revealed that the subjects in the high verbal conditions significantly out-performed those in the low verbal conditions. This was so, however, only if the subjects' explanations for the conservations were taken into account.

Rattan concluded from the results of his research that concepts can exist at different levels of sophistication; i.e., the subjects in the high verbal instruction group possessed a more fully developed concept of invariance since they were aware of the logical necessity of their conservation responses.

In his conclusions regarding the role of verbal instructions in learning the various conservations, Rattan asserted that verbal instructions orient the subject's attention to the relevant features of the stimuli, releasing him from an overpowering visual display. Once the subject is released from this vast visual array of stimuli and is directed to concentrate on a few relevant features of them, he is free to operate at a more symbolic level.

In only three studies where conservation of continuous quantity was successfully induced, did the subjects perform or assist in the transformation of the substance (Inhelder et al, 1966; Goldschmid, 1968; Brisson and Bereiter, 1967). In six other successful studies of this type, the subjects watched as the experimenter manipulated the substance (Brisson, 1966; Engelman, 1967; Lefrancois, 1968; Sigel et al, 1966; Sullivan, 1967; Waghorn and Sullivan, 1970). It is apparent that the results of Rattan (1971) regarding manipulation and demonstration are supported by the above literature on liquid invariance.

An examination of the above studies, with reference to the methods of instruction used to teach conservation, showed that some combination of the following two methods were used:

- (1) the subject assisted in the transformations and/or the subject watched the transformations done by the experimenter;
- (2) the subject received or did not receive verbal instructions from the experimenter regarding the transformations.

The important point concerning transformation of material in demonstrating the processes of compensatory relations, reversibility, and identity seems to be that the substance must be transformed, whether by the subject or the experimenter.

The role of instructions, as suggested by Rattan (1971) seems to be to point out the relevant aspects of these transfor-

mations. That verbal instruction can fill this role is verified by the literature. Examination of the studies of Brisson (1966), Brisson and Bereiter (1967), Engelman (1967), Goldschmid (1968), Inhelder et al (1966), Lefrancois (1968), Sigel et al (1966), Sullivan (1967) and Waghorn and Sullivan (1970), shows that their instructions focus the subject's attention on the important aspects of the various transformations performed, i.e., compensatory relations, reversibility and identity.

The verbal instructions in Sullivan's (1967) study focus the subject's attention on the reciprocal relationship of the dimensions of the containers used to demonstrate compensatory relations. In this study a model on film demonstrated this principle while verbalizing it. He mentioned that when the glass is tall and narrow, the level of the water is high, and when the glass is short and wide, the level of the liquid is low, but that both glasses contain equal amounts of water.

In another study, (Inhelder et al, 1966) the instructions directed the subjects' attention on reversibility as well as compensatory relationships. The subjects were required to predict the outcome of liquid transformations in which water flowed from two identical standard containers into a tall, narrow glass and into a short wide glass simultaneously. Then the water flowed into a pair of glasses identical to the original ones. Subjects were encouraged to reconcile their predictions with what actually occurred during these transformations.

Brisson (1966) directed the perceptions of his subjects by having them compare equal amounts of liquid in identical containers before transformation, again after pouring the water into unequal glasses, and finally after returning the liquid to its original containers. In this case, his subjects' attention was guided to the processes of reversibility and compensatory relations. These few examples serve to illustrate that the role of verbal instruction in conservation experiments is to guide the subjects' attention to the relevant aspects of the transformations. They also demonstrate that language can be used in many ways to achieve this purpose.

From the above discussion, it can be seen that a critical aspect in teaching conservation involves having the subjects attend to the relevant aspects of a given transformation. When demonstrating reversibility the experimenter should direct the subjects' attention to the fact that material of a given shape can be transformed to a different shape and then returned to its original form without altering its quantity. Similarly, when illustrating identity, it should be pointed out to the subject that despite changes in the substance's shape, nothing has been added or taken away; it is the same material. The manner in which verbal instructions point out relevant aspects of the various transformations appears to determine how well the conservation tasks are learned.

Although verbal instruction serves as a method for pointing out the relevant aspects of transformations used in inducing conservation, it has been shown that there are at least several

ways to do this. The present study focuses on one particular method of teaching conservation of continuous quantity originated by Halford.

Overview of Halford's Learning Theory Model of Conservation of Liquid

G.S. Halford (1970) proposed a learning theory approach to the acquisition of conservation of liquid substance. The theory holds that learning enters into the process of conservation acquisition when children need to discriminate among quantities. In order to be a conserver a child must learn the relationship between two sets of cues--quantity cues and dimension cues.

Children must learn the relationship between these two sets of cues because only by considering the dimension cues along with the quantity cues do the latter cues take on any relevance. For example, a child may recognize that no material has been added or subtracted and that the material may be returned to its original container, thereby assuming its original dimensions, yet he may not be able to conserve. Halford accounts for this inability to conserve by postulating that the child ignores these quantity cues in favour of the dominant dimension cue of height. Thus, when quantity cues are contradicted by dimension cues, quantity cues are irrelevant to the child.

In order to make consistently correct conservation judgements, a child needs reliable indicators of quantity. Since only one

dimension, eg. height, is not a reliable indicator of quantity, the child needs to learn the relationship between the three dimensions and quantity. A given height, length and width imply only one quantity. Similarly, a given quantity, length, and width, imply only one height. Only as the child learns this relationship among the dimensions and quantity, do the quantity cues take on significance for the child. For example, if liquid is poured from container A to container B, which is identical to A except for one dimension, liquid must be added or subtracted for A to exactly fill B. Also, by simply returning the material to A, the original dimensions cannot be resumed. By considering the three dimensions simultaneously, the child now has a reliable indicator of quantity, thus allowing the quantity cues of identity and reversibility take on meaning for the child.

In order for the cue of compensatory relations to become meaningful to the child, dimensions must be changed reciprocally. It can be seen that if two dimensions are altered simultaneously and reciprocally, nothing being added or subtracted, and if one change in a dimension is given, then the other dimension can have one and only one value. In this way, postulated Halford, the child arrives at the notion of compensation.

To summarize, Halford proposes that there are two sets of cues by which children can make conservation judgements--quantity cues and dimension cues to give them meaning. Consequently, in order to learn conservation, a child must learn the relationship

between these two sets of cues, utilizing them to arrive at consistently correct judgements.

On Conservation: Halford and Piaget

Halford's learning theory model and Piaget's equilibrium theory take differing points of view on most issues in conservation. While Piaget talks of the need to separate one's cognitions from one's perceptions, Halford speaks of the child's need to make his cognitions consistent with his perceptions. Piaget's subject uses such quantity cues as identity and reversibility, but Halford's child makes use of the interactions between quantity cues and dimension cues. Included in both view points is the process of compensation which both agree is the ability of the child to recognize that a change in one dimension can be compensated for by a reciprocal change in another dimension. However, Halford goes one step further and specifies that a change in one dimension leads to one and only one change in another dimension. It can be seen that while Piaget utilizes the cues given by quantity and dimension, he does not specify any relationship between them. Halford, on the other hand, makes this relationship the basis of his theory of conservation acquisition.

Piaget and Halford have separate approaches to the induction of conservation. Piaget's theory emphasizes the use of quantity

cues while Halford (1969) stresses the relationship between quantity and dimension cues. He does this by having the Ss classify containers without any specific instructions concerning their equality or about conservation. Specifically, Halford (1969, 1970) poured liquid from container A to a second container B, of different dimensions but of equal volume. The Ss were then shown various containers that differed from B in only one dimension, e.g., height, breadth. They were required to separate the various containers according to E's instructions. In the first study, Ss were required to sort the containers according to which ones would underfill or overfill B. In the second experiment, E instructed the Ss to separate the containers into categories of taller, shorter, wider and narrower than B. After this training, Ss were given a conservation of liquid test. The control group differed from the experimental group in that the controls had never seen A emptied into B.

In both of these studies, significantly more Ss ($P < .01$) in the experimental group attained conservation than did control Ss. Halford accounts for this difference by hypothesizing that by separating containers into categories, the Ss were actually learning which particular combination of dimensions was not equal to B, as well as which ones were equal to B. In other words, the Ss had to learn to discriminate between those containers whose combination of dimensions was and was not equal to B's dimensions.

The main difference between Halford's study and the present investigation lies in the method of teaching conservation. While

Halford induces conservation indirectly in his Ss, the current study attempts to teach it directly. Halford's indirect method involves having Ss compare variously sized containers to a specific model container, while the Ss in the present study compare the containers to one another. Also, where Halford used categorization of containers as an indirect teaching method, the current investigation teaches the Ss the relationship between quantity and dimension cues directly by focusing on the relevant aspects of the liquids transformations from one shape to another.

The methodology used by Halford to induce the incidental learning of liquid conservation in his Ss was basically compare and contrast. In transforming this subtle teaching method into a direct methodology for inducing liquid conservation, Halford's subtle compare and contrast method was made explicit. An examination of the literature revealed that such a methodology has been developed (Gagne 1968).

In his cumulative learning model, Gagne outlined several stages or levels of learning that, according to him, are necessary for a child to go through in order to acquire the concept of liquid conservation (see Appendix I). These stages range from certain simple S-R connections through multiple discriminations and concepts to complex rules. At the complex rule stage of his model, Gagne includes two steps (specifically #6 & #7) that utilize a compare and contrast methodology in an attempt to induce conservation. These two steps from Gagne's model are, in essence,

the subtle, indirect method used by Halford; the only difference between Halford's method of teaching and the two steps from Gagne's model (which also constitute the teaching method in the current study) is that Gagne is direct and explicit in his teaching methods while Halford is subtle and indirect.

Section II

The Present Investigation

In order to teach conservation this study utilizes steps #6 and #7 from Gagne's cumulative Learning Model. Halford proposes that the quantity cues must be accompanied by dimension cues so that the child can learn the relationship between them. For example, the quantity cues of identity and reversibility become meaningful to the child when he learns that for any given length, width, and height, there can be only one quantity. To teach this relationship, water is poured from one container to another which differs from it in only one dimension. This is exactly the method used in step #6 of Gagne's model.

Halford postulates that in order for the child to learn compensatory relations, reciprocal dimensions must be altered simultaneously. In step #7 of Gagne's model, one dimension is held constant while the other two are simultaneously altered in a reciprocal manner. Thus it can be seen that the essential methods for teaching conservation postulated by Halford are contained in steps #6 and #7 of Gagne's model. (For further details see - The Learning Program - Page 26).

Subjects

Sixty subjects selected from two Thunder Bay Elementary schools were used. Forty of them were randomly chosen from a population of non-conservers between the ages of seven and eight years and were of at least normal intelligence. The remaining twenty subjects were natural conservers of liquid but were not significantly different from the other subjects in age and intelligence. Specifically, the mean age for each group was: experimental group, 7.09 years; natural conservers, 7.23 years; control group, 6.76 years.

Design

The forty non-conservers were assigned to the experimental and control groups in a manner calculated to randomize the effects of age, I.Q., and sex. The twenty natural conservers formed a second control group. The method of determining the natural conservers from the non-conservers is discussed in detail in the pre-test section.

The experiment was carried out in four phases illustrated in Table I as follows:

Table I

OUTLINE OF THE FOUR STEPS FOLLOWED IN THE EXPERIMENTAL PROCEDURE

<u>Treatment</u>	<u>Experimental Ss</u>	<u>Control Ss</u>	<u>Natural Conservers</u>	<u>Lenght of Time between treatment</u>
1. Conservation of Liquid Pretest	Yes	Yes	Yes	Step 2 follows Step 1, immediately.
2. Learning Program	Yes	No	No	Step 3 follows step 2 after 24 hours and 6 days.
3. Conservation of Liquid Posttest	Yes	Yes	Yes	
4. Extinction	Yes	Yes	Yes	Step 4 follows step 3 immediately.

The four phases of the experiment were completed in four sessions. Stages 1 and 2 were carried out the first time the subjects were seen, while Stage 3 was completed the second and third times the subjects were seen. Stage 4 was completed the fourth time that E saw the subjects. All subjects were involved in all parts of the sutdy, except for Stage 2. The control group and the natural conservers did not receive the learning program, but the experimental group did.

The experimental variable in the present study is the learning program. It was administered to the experimental Ss in an attempt to induce the conservation of liquid. The control group and natural conservation of liquid. The control group and natural conservers were not exposed to the learning program. The effectiveness of the program was tested by measuring the amount of learning that had taken place. A post-test of liquid conservation and resistance to extinction were used.

The post-test is a direct test of the effectiveness of the learning program to induce conservation. It allows a direct comparison between the experimental and control groups. Superior performance by the experimental Ss would provide evidence that the learning program had successfully induced conservation of liquid.

Verbal data gathered at the post-test was also analyzed according to the quality of the Ss learning. A S's explanation of his correct answer on the post-test fell into one of three categories: 1) perceptual--an explanation indicating reliance on appearance; 2) symbolic--an answer indicating use of elementary logic, i.e., quantity or dimension cues; and 3) ambiguous. A symbolic explanation meant that the S was aware of the reasons for his correct answer on the post-test while a perceptual explanation indicated that the S was not fully aware of the reasons.

behind a correct answer. An ambiguous explanation might indicate that the S was in a state of transition between a perceptual and a symbolic explanation. By comparing the types of explanation given by the three groups of Ss for their correct answers on the post test for liquid conservation, the differences in the level of sophistication of the acquisition of concept of conservation might be determined for the three groups of Ss.

The quality of the S's learning was also measured by his resistance to the extinction of that learning. For example, a S who has learned the conservation concept at a low level of sophistication; i.e., he is able to give the correct answer to the post test but does not know the reasons for his correct answer, may extinguish while a S has acquired the conservation concept at a high level may maintain conservation. Theoretically, in order to acquire a concept at a high level of sophistication, the S must be able to give the correct answer plus the correct explanation for his answer. By comparing the three groups of Ss according to their resistance to extinction, the level at which a group of Ss has acquired the concept of conservation can be determined.

Statistical Test

The statistic used to test for significance in the post test, the extinction, and level of acquisition of the conservation was a 2 factor chi square in each case.

Apparatus

The apparatus consisted of two identical standard containers and nine comparison containers of varying dimensions. All containers were rectangular in shape and made from plexiglass. They were of the following dimensions:

<u>Container</u>	<u>No.</u>	<u>Length</u>		<u>Width</u>		<u>Height</u>
standard	2	6"	x	6"	x	6"
comparison	1	9"	x	6"	x	6"
comparison	1	6"	x	9"	x	6"
comparison	1	3"	x	9"	x	6"
comparison	1	9"	x	6"	x	3"
comparison	1	3"	x	6"	x	9"

Other apparatus included coloured water and steps #6 and #7 of the cumulative learning sequence of Gagne (1968).

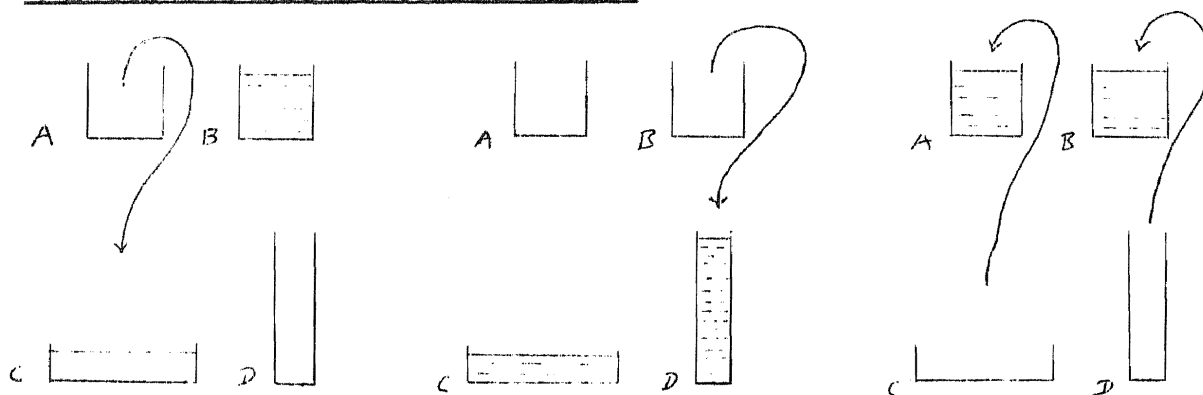
Pretest

Subjects were pre-tested individually on the conservation of continuous quantity in order to separate the non-conservers from the natural conservers. The non-conservers were randomly assigned to the experimental and control groups, while the natural conservers formed a third group.

The pre-test was similar to that described by D. Hyde (1970) (see figure 1). The S was presented with two identical containers A and B, holding equal amounts of liquid. If the S did not agree that these amounts were equal, he was asked to adjust them so

that they were equal. Then, the liquid from glass A was poured into a wide, shallow glass, C, and the S was asked, "Does this container (c) have more, less, or the same amount of water in it than this one (B)?" Next, the water from glass B was poured into a tall, narrow container, D, and S was asked, "Does this container (C) have more, less or the same amount of water in it as this one (D)?" Lastly, the water from glasses C and D were poured back into containers A and B. The S was asked, "Does this container (A) have more, less or the same amount of water in it as this one (B)?" The S must have answered all three questions correctly in order to be classified as a natural conserver; otherwise he was labelled as non-conserver.

Figure 1: Sequence for Pre-Test



The pre-test differed from the classical Piagetian pre-test for liquid invariance in that Piaget returned the water to the original containers after the first comparison. Piaget's procedure allowed A to be compared with B, C, and D, but did not allow C and D to be compared. The pre-test used in the present

study was more complicated since A and B were poured into C and D respectively, allowing C and D to be compared.

Learning Program

The learning program used in the present study is comprised of steps #6 and #7 of Gagne's Cumulative Learning Model (see Appendix I). These particular steps of Gagne's model were selected because they are the processes involved in Halford's theory of conservation.

Halford proposed that in order for a child to be able to make consistently correct judgements concerning conservation, he required reliable indications of quantity. He needed to know the relationship between the three dimensions and quantity; i.e., a given length, width, and height imply only one quantity. From this relationship it can be seen that if any two dimensions are held constant, the quantity will vary with the third dimension. As the child comes to understand this relationship, the quantity cues of identity and reversibility become meaningful to him according to Halford.

Halford (1969, 1970) used this method of holding two dimensions constant and varying the remaining one to teach his Ss conservation. Part of his teaching method involved having Ss categorize containers that differed from a model container in only one dimension into categories of "overfills" or "underfills" the model container. It can be seen that Gagne also uses this

same technique in step #6 of his Cumulative Learning Model.

A further relationship between quantity and dimensions is that of compensatory relations. For example, compensation occurs when one dimension is held constant while the two remaining ones vary reciprocally. Of course, quantity is unchanged.

Halford (1969, 1970) utilized compensatory relations to induce conservation in his Ss. The experimental group of Ss viewed liquid being poured from container A into container B which held the same quantity as container A, but was of different dimensions. Compensatory relations is the method of teaching conservation that appears in step #7 of Gagne's Model. Thus, it can be seen that the essential features for teaching conservation according to Halford's model are found in steps #6 and #7 of Gagne's model.

Post Test

This post test was identical to the pre-test of Phase I, except that after each question, the subject was asked, "How do you know?" His answer was recorded verbatim. All subjects were post tested approximately 24 hours and 6 days after the completion of the pre-test.

Extinction

All the conservers were given six extinction trials, administered individually. The purpose of these extinction trials was to determine the degree of the resistance to extinction of the induced learning.

A measure of the degree of the resistance to extinction serves as a measure of the quality of the subject's learning. When a subject acquires the concept of liquid invariance he may do so in one of two ways. He may acquire what Smedslund (1961a) refers to as a pseudo concept; i.e., simple response learning. On the other hand, the subject may simply learn the correct response to a conservation concept because he knows the logical reasons behind his correct answers; i.e., he has a genuine concept of conservation. It follows, then that a pseudo concept should be fairly easily extinguished, whereas a genuine concept should not be easily extinguished.

The extinction procedures were quite similar to the method involved in learning conservation (see Diagram I). The difference was that when the two identical containers were compared at the end of the transformation, the two amounts of water were unequal. This was accomplished by adding or subtracting water from the containers. On three of the trials container A had more water than container B, and vice versa.

After each transformation, the Ss were asked, "Does this container have more, less or the same amount of water as this one?" "How do you know?" The Ss answers were transcribed verbatim.

Section III

Results

In order to determine whether or not the experimental group of Ss had learned to conserve liquid substance, they were compared to the control group of Ss on a conservation of liquid post-test. Out of the 20 Ss in the experimental group who were exposed to the learning program, 9 learned to conserve. None of the control group became conservers during the experimental period. A chi square analysis showed that the experimental group of Ss was significantly different from the control group on the conservation of liquid post test - ($\chi^2 = 11.6$, d. f. = 1, $P < .001$).

Once it was established that the experimental group had acquired the concept of conservation, the next question to answer was: how well had they learned this concept? The answer to this question lay in two comparisons of the experimental group with the natural conservers on post-test trials: Once twenty-four hours after the screening of the natural conservers and the teaching of conservation to the experimental Ss, and then six days later. In other words, was the performance of the experimental Ss and the natural conservers on the liquid post-test related to the method of acquisition of the conservation concept, or were these variables unrelated?

On the first comparison, it was discovered that in the experimental group, 9 of the 20 Ss had learned to conserve, while 16 of the 20 natural conservers passed the conservation of liquid post-test. The two variables of method of concept acquisition and performance on the post-test were shown to be strongly associated by a chi square for independence ($\chi^2 = 5.22$, d.f. = 1, $P < .05$).

The second comparison six days later showed that now only 7 of the experimental group of Ss continued to conserve while 16 of the 20 natural conservers were still able to succeed on the conservation post-test. Chi square analysis showed that these two factors, mentioned above were even more strongly associated ($\chi^2 = 8.28$, d.f. = 1, $P < .01$). In other words, each of the methods of learning conservation is associated with a specific level of performance.

Table II

Shows the number of Ss in the natural and experimental conserver groups that were able to conserve out of the total number of Ss in each group after 1 day and 6 days.

	<u>1 Day</u>	<u>6 Days</u>
Natural Conservers	16/20	16/20
Experimental Conservers	9/20	7/20

During the interval of time between the two conservation of liquid post-tests, conservation remained quite stable in both the experimental and natural conserver groups of Ss. Four of the experimental Ss reverted to non-conservation while two experimental Ss became conservers. In the natural conserver group, two Ss became non-conservers only to be replaced by two Ss who became conservers.

The last comparison between the experimental and natural conserver groups involved the verbal reasons given by the Ss for their answers after each transformation of liquid in the post-tests. These reasons were analyzed and categorized according to whether they were symbolic, perceptual or ambiguous as defined in the method section, (Page 23). The first post-test revealed that nine of the Ss in the experimental group who were able to conserve were also capable of giving reasons categorized as symbolic. Of the remaining eleven non-conserving Ss in this group, two gave symbolic answers, two gave ambiguous responses and seven gave perceptual replies. There were sixteen Ss capable of symbolic answers among the natural conservers, while the remaining four responded on a perceptual basis.

It was discovered that all the Ss who were still conservers after the second post-test (16 of the Ss in the natural conserver group and 7 Ss in the experimental conserver group) gave reasons for their choices that fell into the symbolic category. Of the remaining 13 non-conservers in the experimental group, one responded on a symbolic level, 2 gave ambiguous replies and 10 responded with perceptual answers.

The natural conserver group repeated the performance it gave on the first comparison; i.e., 16 of them replied with symbolic answers while 4 gave perceptually based replies.

Table III

Shows the number of Ss in the natural conserver and experimental conserver groups whose answers were categorized as symbolic, perceptual or ambiguous after 1 day and 6 days.

<u>Experimental Group</u>	<u>Symb.</u>	<u>1 day</u>		<u>Symb.</u>	<u>6 days</u>	
		<u>Perc.</u>	<u>Amb.</u>		<u>Perc.</u>	<u>Amb.</u>
Conserved	9			7		
Did not Conserve	2	7	2	1	10	2
<u>Natural Conserver Group</u>						
Conserved	16			16		
Did not Conserve		4			4	

Responses categorized as symbolic indicated the use of elementary logic on the child's part; i.e., use of quantity and/or dimension aspects of cues. Some examples of these symbolic responses are:

"When you started out they were the same amount, so they should be the same now. You just put them into differently shaped jars."

"This one is higher, but this one is fatter".

"This one is wide and this one is skinny but the amount is the same."

Each S who had passed the second conservation of liquid post-test underwent 6 extinction trials. In none of the Ss was learning extinguished.

Section IV

Discussion

The results of this study point to several conclusions. Firstly, it was demonstrated that direct training utilizing a direct, explicit compare and contrast method of teaching can facilitate the acquisition of liquid conservation. Secondly, it was shown that the groups of Ss in this study who had been taught liquid conservation by this particular compare and contrast method did not learn this concept as well as those Ss who had acquired it naturally (the natural conserver group of Ss). Thirdly, this study showed that generally, those Ss who were able to conserve on the two liquid conservation post-tests; i.e., both the acquired answers. In other words, if Ss were able to conserve, they were generally able to account for their choices in terms of elementary logic. Conversely, those Ss who were not capable of conserving did not usually account for their answers using elementary logic. Instead, their choices were usually made on a perceptual basis, and, in some cases, these answers were completely ambiguous. Fourthly, the effectiveness of the teaching method used in the present study was demonstrated by the permanence of the learning in the experimental group of Ss. Over the 6 days, between the two post-tests of conservation, a majority (78%) of the experimental Ss retained the concept of conservation taught by the compare and contrast method of the current study. Also, none of the experimental Ss extinguished as a result of the extinction trials. It should also be noted that none of the natural conservers extinguished either.

There were, however, those Ss who were not capable of conserving, yet gave reasons for their answers categorized as symbolic. It is hypothesized that these Ss had not quite completed the transition from a pre-conservation state of equilibrium (Piaget's pre-concrete operational thought stage) to a qualitatively higher state of equilibrium (Piaget's concrete operational thought stage).

In other words, it is postulated that, at the time of the post-tests, these Ss were still in the process of changing from one stage of intellectual development to a qualitatively higher one.

Implications

The notion of compare and contrast referred to earlier is a very basic one. We become aware of things only when we are able to distinguish them from their surroundings; e.g., we know sound because we are able to distinguish it from silence and vice versa. Yet sound does not exist separately from silence, because without silence, from what would one distinguish sound? And again, vice versa. Clearly, these two must co-exist, and in doing so, give each other meaning. This concept can be applied widely to many areas of perception and learning.

Theoretical work involving the compare and contrast method could take the form of using this model to develop learning programs to induce other types of conservation; e.g., volume, weight, area, etc. Also, the compare and contrast methods of inducing conservation; e.g. Piaget, Gagne, etc.

Comparisons between conventional teaching methods and the method of compare and contrast could be made to determine their relative effectiveness. However, in order for such comparison to be meaningful, the teaching process must be made explicit in all cases. For the most part, conventional teaching methods, e.g., lectures, seminars, involve the gathering of information by the student with little, if any, analysis. The data that the students receive in this way is largely meaningless, since it is unrelated to other facts; i.e., it is static. How can anyone be expected to understand the full implications of this data when it is in a partial vacuum?

Surely the way to make data meaningful is to relate it to other data by comparison and contrast. When data is compared and contrasted, a dynamic process to make data meaningful is in operation that contrasts markedly with the rather stilted, static process of gathering the facts in partial isolation.

In this way, the learning process is emphasized, not the end products of learning and the student is free to become actively and creatively involved in the process of learning.

A good example of the feasibility of the compare and contrast method of learning is the award-winning popular T.V. show for children called "Sesame Street". Recognition and counting games on this program seem to evidence a compare and contrast method. Only now are other shows imitating its format, thus helping to realize this method's effectiveness.

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APPENDIX I

Rule: Compensatory changes in volume produced by l & w , when h is constant

Rule: Compensatory changes in volume produced by l & h , when w is constant

Rule: Compensatory changes in volume produced by h & w , when l is constant

Rule: Liquid conforms to container in w & l , but maybe less in h .

Rule: Increase in volume by change in l ; w & h constant

Rule: Increase in volume by change in w ; l & h constant

Rule: Increase in volume by change in h ; l & w constant

Rule: Liquid volume as cumulative slices of area

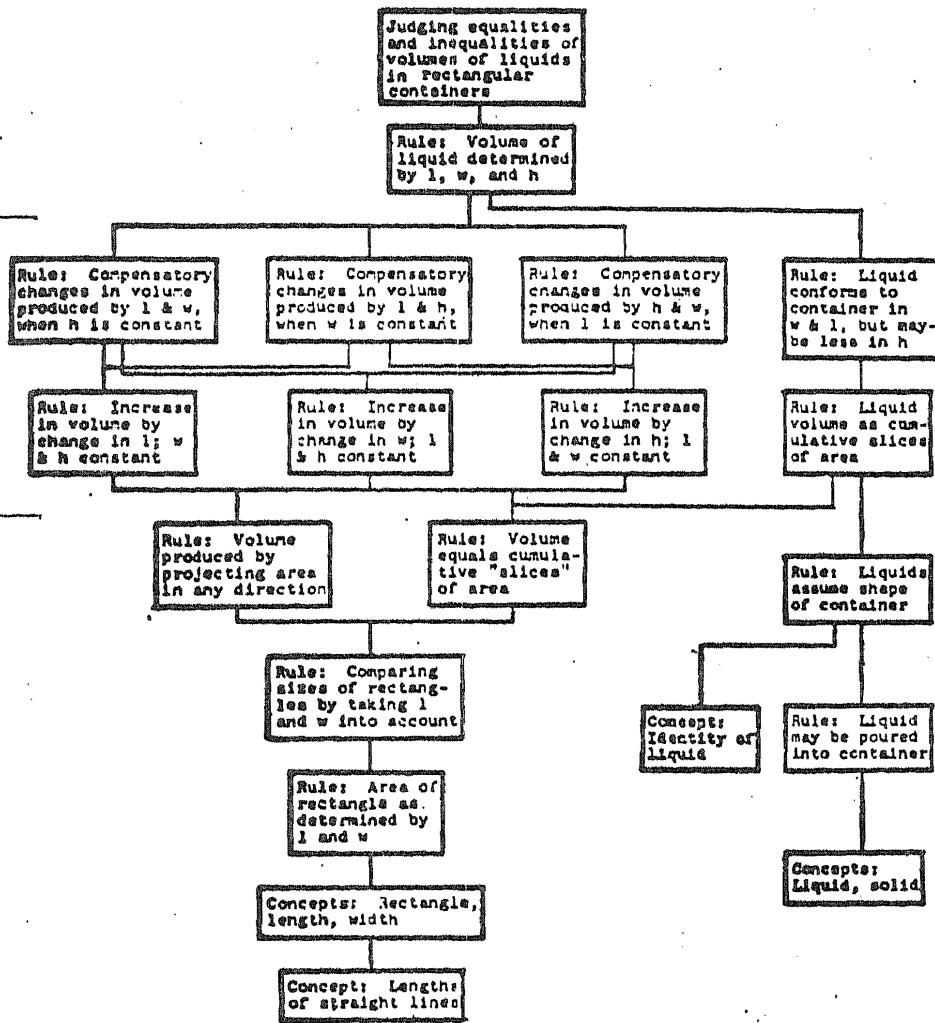


FIG. 3. A cumulative learning sequence pertaining to the development of nonmetric judgments of liquid volume.