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Thirty-seven normal and 33 gifted children from kindergarten classes and 26 retarded children from special classes with mean mental ages of 76 months, 80 months, and 72 months respectively, were initially tested for their understanding of the terms more, same, and less. All who had failed conservation of substance pretests using juice, sand, clay, and paper were then put through a programed five-stage sequence of conservation training with posttesting after each stage. When a child exhibited conservation with all four materials, he was given two extinction questions which tested the stability of the conservation concept. The main differences between groups were on errors during training, extinction, and explanations. Retardates were significantly more susceptible to extinction of conservation responses (p .05) and further study is suggested since this would make a difference in performance if retarded children come out of learning experiences with empirical hypotheses and normal ones with logical certainties. However, no relationship was found between general intelligence level and intuitive concept formation. Eleven tables and a 15-item bibliography are given. (SN)

# ACQUISITION OF CONSERVATION OF SUBSTANCE IN NORMAL, RETARDED, AND GIFTED CHILDREN *

Paper presented at a Seminar held in connection with the
Conference on Preschool Education
at The Ontario Institute for Studies in Education
November 15 to 17, 1966

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Carl Bereiter

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# ACQUISITION OF CONSERVATION OF SUBSTANCE IN NORMAL, RETARDED, AND GIFTED CHILDREN[1]

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In the present study, acquisition of conservation of substance was used to explore possible qualitative differences in intellectual functioning among gifted, normal, and retarded children. Although it appears to be widely believed that qualitative differences exist—that more intelligent children are able to formulate concepts faster, generalize to different problems more widely, and somehow incorporate new concepts more solidly and in a more complex fashion into their cognitive structures—there is virtually no empirical evidence of such differences, either among the gifted (Gallagher, 1960) or the mentally retarded (Johnson, 1958; Johnson and Blake, 1960; Rosenberg, 1963; Wallace, 1965).

Conservation of substance refers to the principle that a given amount of substance remains constant, even though its shape or distribution is altered. The classical method of testing for conservation of substance, derived from Piaget and Inhelder (1941), is to show a child two equal amounts of substance in the same form (clay in balls or liquid in identical containers), then change one into another shape, and ask the child if the new shape has the same amount of substance as the one that was not altered. Generalization is tested by the use of different substances. Stability is tested by exposing the child to deceptive demonstrations that appear to violate the principle of conservation—as when a bit of material is removed by sleight of hand (Smedslund, 1961).

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[1]This study was supported by a grant from the National Institute of Child Health and Human Development, United States Department of Health, Education, and Welfare. Project HD 02125-01. It was conducted while Dr. Brison was at Central Michigan University and the University of Illinois and while Dr. Bereiter was at the University of Illinois.

The authors wish to thank Mrs. Offra Gerstein for her assistance in organizing the collection of data. The cooperation of Dr. Robert Cooley, Dr. Lowell Johnson, and Mr. John Fennessey, respectively of the Champaign, Urbana, and Danville, Illinois public schools, was greatly appreciated. Thanks are also due to many principals and teachers who allowed the children in their classes to be used as subjects.

The acquisition of conservation of substance was selected as a medium for the exploration of cognitive differences because it possesses the following characteristics:

1. It is a natural rather than an artificial learning task, that is, it is eventually accomplished by children without special instruction.
2. The age gradient for normal acquisition of conservation is sufficiently steep that it is possible to find substantial numbers of children within a relatively narrow age band who have not acquired it, yet who are not far removed from the normal age of acquisition. It is normally acquired by a child when he is in the mental age range of 7 to 8 years. In the present study all children were within the 6-year mental age range, their chronological ages varying inversely with intelligence level.
3. It is subject, at least partially, to experimental induction (Brison, 1965; Flavell, 1963; Sullivan, 1966; Wallach, 1963).
4. It is logically independent of particular items of information, so that differences in acquisition and transfer are less likely to be confounded with differences in the possession of relevant ancillary information.
5. It is sufficiently well defined that clear-cut criteria of acquisition, transfer, and extinction can be applied. Thus the task has many of the virtues of contrived "laboratory" learning tasks, while possessing more obvious relevance to normal intellectual development.

The present study used Brison's training procedure (1966) as a basis for comparing concept acquisition in normal, retarded, and gifted children. Brison initially pretested conservation of substance using liquid, sand, and clay. The subjects were then randomly divided into Experimental and Control groups. The Experimental subjects were trained in small groups of seven children, including two children who were not subjects and who possessed conservation of substance before the experiment started. The children were shown identical cylindrical glass containers with unequal amounts of juice. The examiner then poured the larger amount into a wider container and the smaller amount into a narrower container and asked the children to point simultaneously to the glass which had more juice to drink. The juice was returned to the original glass and the subjects were given the amount they had chosen to drink. A child who gave the correct prediction (in the first trials usually a conserving subject) was asked to explain why he got more juice to drink. This procedure was repeated three times per child on the first day, and twice per child on the second day. On the second day, on one trial the larger amount was poured into the narrow glass. The children were then posttested on the conservation of substance tasks using liquid, sand, and clay, and were given an extinction item which tested their ability to retain the concept when faced with an apparent contradiction of the concept. Training was in the conservation of inequalities of substance, and the children had to transfer the concept to the conservation of equalities.

Approximately 50 percent of the Experimental group showed some evidence of conservation of substance on the posttest. The concept was transferred to the materials not used in the experimental training—clay and sand. Those subjects who acquired the same level of conservation during the experiment as those who had conserved before the experiment performed similarly on the extinction item. This training method formed the basis for training in the present experiment.

Inhelder (1966) in her doctoral dissertation used conservation of substance, weight, and volume, and Piaget's transitivity problem as a means of studying reasoning in retardates and also to develop instruments for diagnosis of mental retardation. She found in retardates: (1) a lag in acquisition of conservation of substance, (2) a failure to reach Piaget's stage of formal operations, (3) a tendency to oscillate more than normals between operational and pre-operational stages, (4) a fixation at one level of operational thought which she explained by the existence of a "false equilibrium" characterized by a certain "viscosity," which resulted in the persistence of traces from the previous level much longer than in the normal child. In this early work (completed in 1941), Inhelder did not report statistical comparisons on the above differences between normal and retarded, and in many instances it is difficult to arrive at an operational definition of the differences she observed.

*Statement of Problem*

The following questions were investigated in this experiment:

1. Do more intelligent children acquire conservation with less training?
2. Are more intelligent children capable of acquiring conservation from training that is less directly related to the conservation task?
3. Once the concept of conservation is acquired, is transfer to different material related to intelligence level?
4. After the concept of conservation is acquired, is the more intelligent child more likely to resist giving up the concept when he is faced with conflicting evidence?
5. Is oscillation between conservation and nonconservation related to intelligence level?

## *METHOD*

### *Synopsis*

Groups of Normal, Retarded, and Gifted children, all with mental ages between 5 years, 4 months and 7 years, 3 months, were initially tested for their understanding of the terms *more*, *same*, and *less*. Those who comprehended these terms were then given conservation of substance pretests using juice, sand, clay, and paper. Nonconserving normal ($N$ = 37), retarded ($N$ = 26), and gifted ($N$ = 33) subjects were then put through a programmed five-stage sequence of conservation training with conservation posttesting after each stage, so that the effect of training could be analyzed. The training sequence was designed so that successive levels were more directly related to conservation tasks. When a child exhibited conservation with all four materials (juice, sand, clay, and paper), he was considered to have completed the training sequence and was given two extinction questions which tested the stability of the concept of conservation of substance.

### *Subjects*

Normal and gifted subjects were selected from kindergarten classrooms in the Champaign, Danville, and Urbana (Illinois) public schools. Four gifted

subjects were selected from a pre-kindergarten nursery class run by Bereiter. Structured direct teaching was emphasized in this class in contrast to the more typical social-play nursery school situation. The retarded subjects were enrolled in special classes for the educable retarded in the same school districts. The California Short-Form Test of Mental Maturity, 1963 Revision, Level 0 was used as a selection device for normal and gifted kindergarten children. This test was administered in small groups of six to eight children by university research assistants. The retarded sample was selected using individual intelligence tests (WISC or Stanford-Binet) administered by school psychologists.

TABLE 1.—IQ, chronological age, and mental age characteristics of Experimental groups

| Group | IQ | | | CA[a] | | MA[a] | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Range | *SD* | Mean | Range | Mean | Range | *SD* |
| Normal (*N* = 37) | 108 | 100-116 | 12.1 | 71 | 64- 75 | 76 | 72-83 | 2.97 |
| Retarded (*N* = 26) | 69 | 62- 75 | 2.2 | 104 | 96-128 | 72 | 64-87 | 4.1 |
| Gifted (*N* = 33) | 129 | 124-142 | 9.3 | 63 | 57- 68 | 80 | 74-83 | 3.0 |

[a]In months

Characteristics of the three groups are presented in Table 1. The mean mental ages of the three groups were: Gifted, 80 months; Normal, 76 months; and Retarded, 72 months. An analysis of variance of the mental ages showed that the Retarded group was significantly lower than the Gifted and Normal groups ($p < .05$). The mean difference of four months between the Gifted and Normal groups was not statistically significant. The higher mean mental age of the Gifted group was due to the fact that the experiment started on approximately December 1, 1965. Younger children (chronological age from 4 years, 9 months to 5 years, 0 months) were not in school at this time, so it was necessary to use older gifted children with a higher mean mental age. The use of preschool gifted subjects would have introduced another variable—effect of schooling on a child's reaction to the experimental training sequence. It seemed advisable to retain the small mental age difference rather than introduce a new factor. The four nursery school children who were used had been exposed to instruction of a more formal nature. The lower mean mental age for the Retarded group resulted because a higher percentage of retardates in the upper levels of the mental age range exhibited conservation.

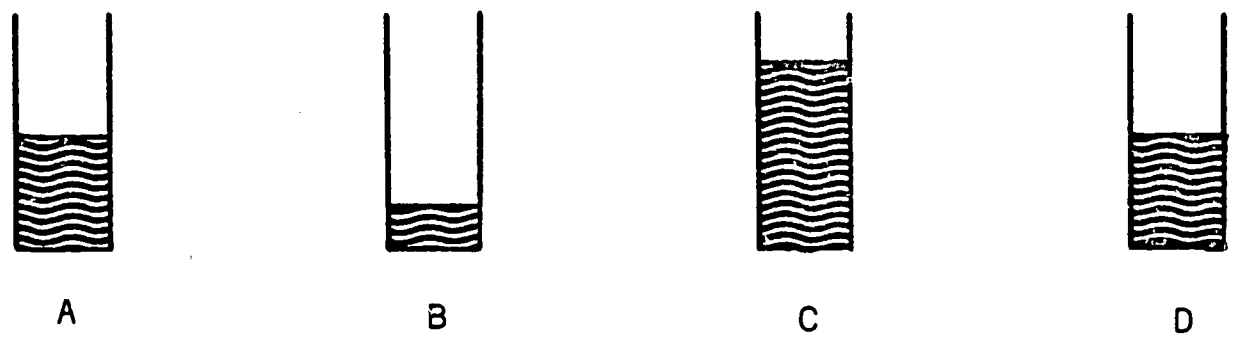
*Apparatus*

The materials used for the conservation of substance questions were: play dough (in 3½-ounce balls), white sand, six-inch squares of paper, and a red fruit-flavored drink. This drink was also used in experimental training sessions. Regular cylindrical drinking glasses served as containers. Extinction items

required a glass with the same outside dimensions as the glass used for post-testing, but with a thick glass bottom. The exact dimensions of the glasses are given in the description of the conservation testing.

*Procedure*

Pretest of Verbal Concepts. Comprehension of the terms *more*, *same*, and *not as much* was tested in the following manner: the child was presented with four identical cylindrical glasses, two of which contained the same amount of juice (A and D), one contained markedly less juice than the other (B), and one contained more (C).




The examiner asked the following four questions:

1. (Pointing to A) "Which glass has *more* juice to drink than this one?"
2. (Pointing to D) "Which glass has the *same* amount of juice to drink as this one?"
3. (Pointing to A) "Which glass has *not as much* juice to drink as this one?"
4. (Pouring enough juice from C into D so that C equals D and pointing to C) "Which glass has the *same* amount of juice to drink as this one?"

In order to qualify for the conservation of substance testing, the subject had to answer correctly all four of the preceding questions.

Pretests of Conservation of Substance. The general examining procedure for all conservation questions was the same. First, the examiner showed the child two equal amounts of whatever material was being used in that question—juice, sand, clay, or paper. He stressed the equality of the two amounts by saying: "See, they have the *same* amount of _____." The examiner then changed one of the objects to another shape and asked: "Does this (pointing to the new shape) have *more* _____, or the *same* amount of _____, or *not as much* _____, as this one (pointing to the original)?" When a child answered this question, the examiner replied: "Why do you think so?" If the child simply restated his original answer—for example, "Because it has *more* (*same*, or *not as much*)"—in response to this question, the examiner said: "Yes, but why does it have *more* (*same*, or *not as much*)?" These explanations were recorded and scored later.

All explanations to *same* responses were scored as *adequate* or *inadequate*. Adequate explanations either had some reference to the original equality of the two objects or attempted to show that change in one dimension (height) was

compensated for by change in another dimension (weight). A statement that nothing had been added or taken away was also scored as adequate. Sample responses were: "It was the *same* as before"; "They are still the *same*"; "If you put it back it will be the *same*."

Every other type of explanation was scored as inadequate. A typical inadequate explanation was a simple restatement of the action completed, for example, "You rolled it up." Reference to the new shape of the object as originally something else was scored as inadequate unless there was some explicit reference to the original equality. The response "It was in there" (pointing to the original glass from which the juice was poured) was scored as inadequate. Two judges independently scored 1,252 responses, and the percentage of agreement was 93.

The following ten items were the basis of the pretest for conservation of substance. The same items were used after each level of training was completed, but their number varied according to the child's response. This procedure will be described later. The ten items were:

1. Juice in two 4" × $2\frac{1}{4}$" glasses—one poured into a narrower glass.
2. Juice in two $4\frac{1}{2}$" × $2\frac{3}{8}$" glasses—one poured into a wider glass.
3. Juice in two $4\frac{3}{4}$" × $2\frac{1}{2}$" glasses—one poured into a narrower glass.
4. Sand in two $4\frac{1}{2}$" × $2\frac{1}{2}$" glasses—one poured into a wider glass.
5. Sand in two 4" × $2\frac{1}{4}$" glasses—one poured into a narrower glass.
6. Clay in two $3\frac{1}{2}$-ounce balls—one made into a sausage.
7. Clay in two $3\frac{1}{2}$-ounce balls—one made into a star.
8. Clay in two $3\frac{1}{2}$-ounce balls—one made into a pancake.
9. Two 6" squares of paper—one crumpled into a ball.
10. Two 6" squares of paper—one folded twice so that when held flat it was one-quarter the size of the unfolded square.

The procedures for the use of conservation items for both initial pretesting and posttesting after each training level, were intended to be as follows: Administer questions on all ten items for the pretest; after each training level has been completed, ask the question based on the first item for each material (items 1, 4, 6, and 9); if the subject responds by saying the amount is the *same*, then ask the question based on the next item with that material, and proceed to the third item (in the case of juice and clay) only if the question based on the second item is answered correctly.

Two of the experimenters administered the type of conservation test which was intended to follow each training level as a pretest instead of going through all ten items with questions. This abbreviated form of pretest was given to 6

of the 37 normal subjects, 13 of the 26 retarded subjects, and 6 of the 33 gifted subjects. The percentage of retarded subjects selected by this method was higher than in the other two groups. In order to determine if this had a biasing effect on the sample, it was necessary, first, to examine the criteria for selection of the samples, and then to see whether any of the subjects who were eliminated after taking the full pretest would have been retained in the Experimental groups if they had instead been given the abbreviated pretest.

The criteria for selection as nonconservers were:

1. No *same* responses accompanied by *adequate* explanations.
2. Not more than three *same* responses accompanied by *inadequate* explanations.

There were 19 subjects who were given the complete pretest and eliminated because they failed to meet the above criteria. Of these 19, only one would have been included in the study if he had received the shorter version of the pretest. That is, 18 of these 19 subjects either had *same* responses accompanied by adequate explanations on the first question for each material or a total of four *same* responses on these four questions. It seems unlikely that the shorter pretest given to a higher proportion of retarded subjects resulted in the inclusion of enough conserving subjects to significantly bias the sample.

The total number of *same* responses for the three groups was: Normal, 10; Retarded, 5; and Gifted, 3. The complete pretest for all the subjects was scored as if they had been given the abbreviated pretest. The difference between groups and the average number of *same* responses per subject was not significant.

Extinction Items. These were questions designed to test the stability of the concept of conservation. They involved an apparent contradiction of the child's concept and required firm certainty in order for the child to continue to assert conservation. Two extinction items were used—one with juice and the other with clay. They were given when the subject exhibited conservation for all four materials.

A. Juice extinction: A standard conservation item using juice poured into a narrow glass was administered. After obtaining a *same* response from the subject the examiner surreptitiously removed the original glass from which the juice had been poured and replaced it with a glass of the same outside dimensions but with a thicker glass bottom. The juice was then poured from the narrow container into the thick-bottomed glass. The examiner pointed out that the level was now higher in this glass and asked if the child still thought they had the same amount of juice. Then, depending on the subject's reply, he asked: "Why not?" or "Then why is the juice higher in this one?"

B. Clay extinction: For this item, one of the clay balls was hollowed out so that the outside appearance was the same but it actually had less clay. The hollow ball was then made into a cross and the conservation question was asked. At this time, it was not apparent that the cross had less clay. When it was returned to a ball again the examiner pointed out that it was smaller than the other ball and asked: "How did that happen?"

Scoring categories for each extinction item were: Logical Certainty—0, and Relinquished—1. In order to qualify for the Logical Certainty category, the

subject had to show his certainty that the two objects *should* still have the same amount of substance. There were two sub-categories in the Logical Certainty classification:

*a)* Some logical explanation was offered for the *apparent* difference in amounts. Typical explanations were: "They must not have been the same when they started" and "You spilled some from the other glass." Some children spotted the thick bottom of the glass and used this as an explanation.

*b)* Either no explanation was offered for the *apparent* difference in amounts, or an inadequate explanation was given but the subject remained convinced that the two objects must have the same amount of substance. These answers were often, but not necessarily, accompanied by reference to the original equality of the objects.

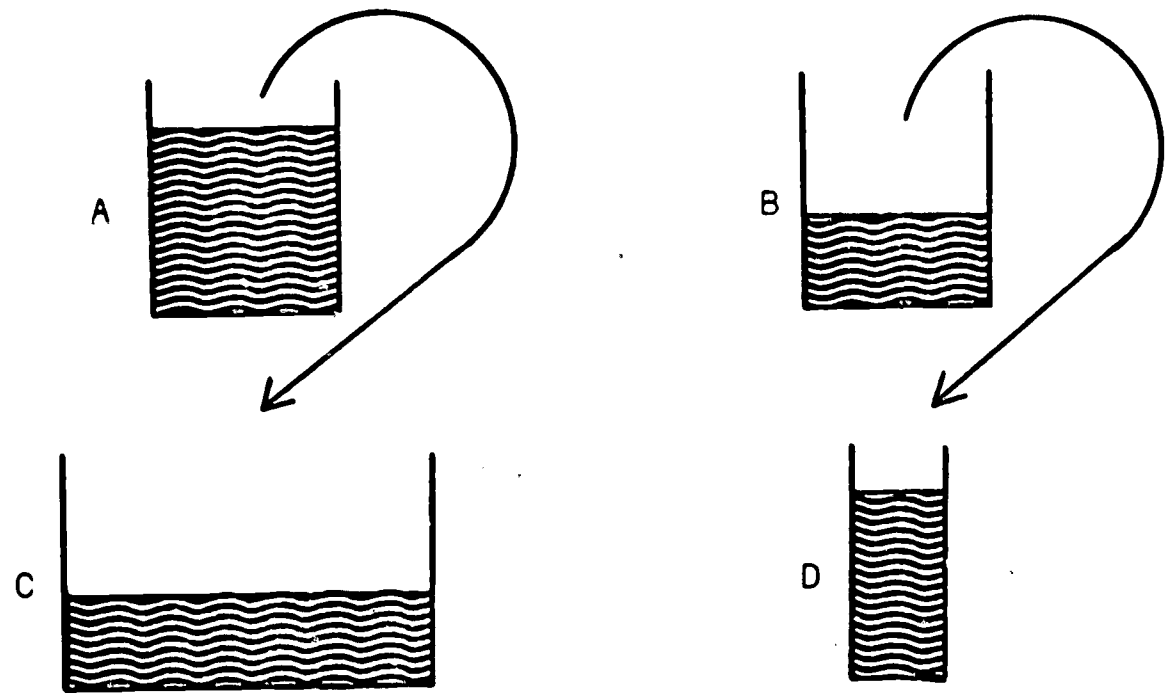
In order to qualify for the Relinquished category, the subject had to admit that there was a change in the amount of substance. No explanation was offered for the change and the concept was seemingly relinquished. If the subject relinquished on both items, he received a total score of 2.

Two judges independently scored 29 explanations and the percentage of agreement was 98. The two sub-categories of Logical Certainty were treated independently in arriving at this degree of scoring reliability.

Training Sequence. Three progressively higher levels of training with juice and two levels with clay were provided. The juice levels preceded the clay levels in the sequence. The first two levels of juice training and the first level of clay training involved work with unequal amounts of substance. The third juice level and the second clay level involved direct training with equal amounts of substance. Juice Level 1 took two sessions, which were conducted on two successive days. The other training levels were all conducted in separate single sessions. Posttests were given at the beginning of a training session and followed the last session. The elapsed time between training levels varied from three to five days. The procedure for training levels follows:

A. Training with Juice—Level 1: In the first session 7 children were grouped around a table upon which were two identical cylindrical glasses with unequal amounts of juice in them. The group consisted of 5 nonconservers from one of the Experimental groups and 2 conservers. The number of nonconservers varied from 3 to 6, and sometimes only 1 conserving child was present. The examiner asked the children to look at the glasses, and elicited from them a statement that the glasses had different amounts of juice in them. He then said: "I am going to pour this one that has more juice (A) into this glass (C), and this one which has not as much juice (B) into this glass (D)." The examiner then said: "I know that you all like juice; which one (C or D) would you take if you wanted more juice to drink?" He asked all the children to point simultaneously to the amount they wanted. If a child appeared to change his mind when he saw children pointing to another glass, the examiner asked him which one he chose first. The examiner then said: "I am going to pour these back into these glasses (A and B)." After pouring them he said: "Now I'll give everybody who chose this glass (C) one like this (A), and everyone who chose this glass (D) one like this (B)." A glass (pre-poured) with the same amount of juice as A or B was then placed in front of each child. The examiner demon-

strated that the children who chose the wider glass had received more juice and asked them for an explanation of this phenomenon. After an explanation was given, usually by a conserving child, the examiner restated the explanation. If a satisfactory explanation was not given, the examiner provided one, such as: "It had the same amount of juice as this glass when it started." After this the children drank the juice. The procedure was repeated two more times using different pairs of unequal glasses.




The second experimental training session involved a variation to prevent the subjects from concluding that the wide glass always contained the same amount. The 7 children were seated around a table. The two conserving children (C) and four nonconserving children (X) were placed in the following order with respect to the examiner's position:

X

X C

C X

X X

Examiner

The examiner started with the child on his left, placed two identical glasses with unequal amounts of juice in front of the child, and asked the child to point to the glass that had more juice to drink. He then poured the larger amount of juice into the wider glass and the smaller amount into the narrower glass and asked the child to predict which glass had more juice to drink. If

the correct answer was given, an explanation was called for. The juice was poured back into the original glasses, so that the prediction could be checked. The examiner then proceeded to the second child, who was a conserver, and repeated the procedure with one important change: *The glass with more juice was poured into the narrow glass.* If the child's prediction was correct, the examiner asked for an explanation. The examiner continued to alternate the two procedures as he passed around the table. He gave each child two trials, one of these with the larger amount poured into a narrower glass. Only those children who gave correct predictions were asked for explanations. All of the children were urged to pay attention as each individual was asked his questions.

Level 2: At this level, the experimenter worked with groups of three nonconserving subjects. The same scheme of pouring juice was used as in Level 1, except that after the juice was put into dissimilar containers, one subject was asked to equalize the amounts by pouring from one glass into the other. After each subject had responded correctly when the larger amount of juice was poured into the wider glass, the procedure was reversed and the larger amount was poured into the narrower glass. If the subject responded correctly on this trial, he was then dismissed from the group. If he responded incorrectly, he was given trials alternating the size of glass into which the larger amount was poured until he reached a criterion of two consecutive correct trials. If he responded incorrectly on six consecutive trials after his first two trials, the training at this level was terminated.

Level 3: Groups of 3 nonconserving subjects were used in this level of training. Equal amounts of juice were poured into dissimilar containers on the initial trials. After the child had responded correctly twice by not making any changes in the containers when they contained equal amounts of juice, the examiner alternated trials using unequal and equal amounts of juice. The procedure for unequal amounts was identical to the one used in Level 2. The training criterion was four consecutive correct trials. If the child kept trying to pour from one container to the other, he was given ten trials, and then training at this level was terminated.

B. Training with Clay—Level 1: Groups of 3 nonconserving subjects were used at this level. Two unequal volumes of clay were deformed and the children were asked to equate them. The training criterion at this level was two consecutive correct trials.

Level 2: As in Level 1 of clay training, groups of 3 children were used. Clay balls of equal volume were deformed and the children were asked to equate them. After the subject responded correctly on two consecutive trials, the examiner then alternated trials using equal and unequal balls. The criterion for this training level was reached after four consecutive correct trials. If the child continued to alter the equal amounts, he was given ten trials, then training at this level was terminated.

Procedure Followed for Training Levels and Posttesting. Every subject entered the program with JL and CL equal to zero (that is no subject had had conservation training either juice or clay). Each subject was given Level 1 training with juice and then the conservation posttests. From this point, the subject's route through the program was determined by his failure or success on various test items. The procedure can be illustrated by referring to Figure 1, which is a flow

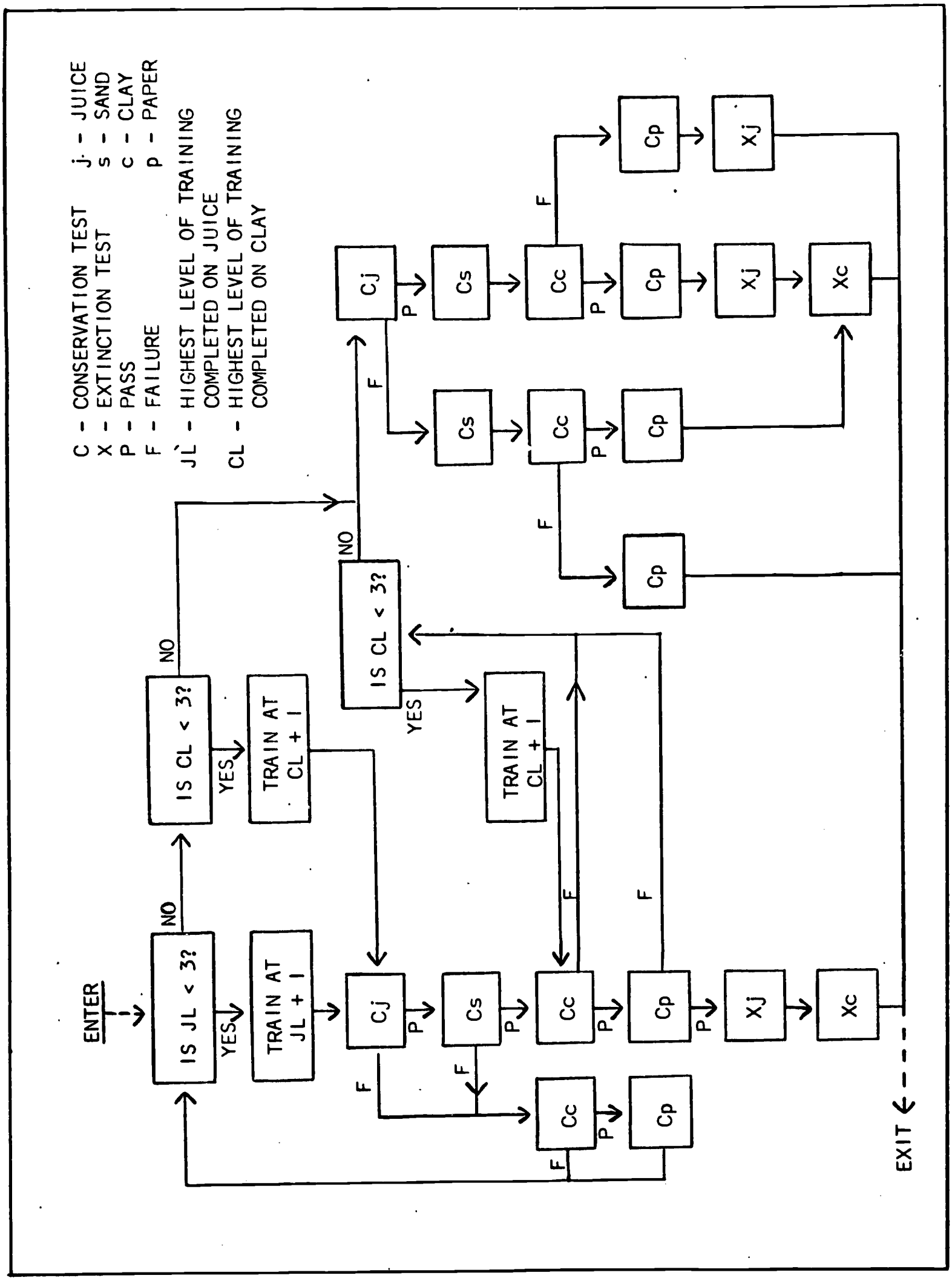



Fig. 1.—Flow chart for training and testing on conservation

chart demonstrating the sequence of training. Suppose a subject finishes Level 1 training with juice and fails to pass all of the conservation items. He then leaves the box Cj by the route marked F (failure) and goes to box Cc (conservation with clay). If he fails this item, he returns to the entry box. Since he has had the first level of juice training, his JL is now 1. He is given Level 2 training with juice and goes again to Cj. Suppose this time he passes Cj and Cs, but again fails Cc. He then goes into the sub-route for training in clay. He receives Level 1 training with clay and then reattempts Cc. If, after one or more levels of training on clay, he passes Cc and Cp, he tries the extinction items on juice and clay and exits from the program. If he goes through his training levels without passing all the conservation items, he proceeds, when his CL is no longer less than 3, to the final test sub-route on the righthand side of the chart. Here he tries all the conservation items and those extinction items for which he is qualified, and then exits from the program. In order to pass on any substance, the subject has to give *same* responses to all the conservation questions given on that substance.

*RESULTS*

Table 2 presents the differences on conservation posttest scores between groups (Normal, Retarded, and Gifted), training levels, and materials, and the interaction between these categories. Total number of *same* responses, disregarding the type of explanation, was the measure of success on the conservation posttest. All juice training levels were combined and treated as one training level and both clay levels were combined in the same fashion. Juice and sand were treated as one

TABLE 2.—Analysis of variance for conservation posttest scores by group, training level, and material

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Groups (A) | 2 | 20.67 | 1.13 | |
| Error (a) | | 93.00 | 18.23 | |
| Training levels (B) | 1 | 34.44 | 22.11 | <.01 |
| Error (b) | | 93.00 | 1.56 | |
| Materials (C) | 1 | 10.34 | 15.82 | <.01 |
| Error (c) | | 93.00 | 0.65 | |
| A × B | 2 | 1.51 | <1 | |
| A × C | 2 | 0.07 | <1 | |
| B × C | 1 | 2.84 | 6.51 | <.05 |
| A × B × C | 2 | 0.95 | 2.17 | |
| Error (bc) | | 93.00 | 0.44 | |

material, as were clay and paper. The difference between the three groups in the acquisition of conservation was not significant. Significant differences ($p < .01$) were found between training levels (B) and materials (C). There were more conserving responses on juice and sand than on clay and paper, and there was also a greater tendency to conserve following training with juice than training with clay. The interaction between levels and materials (B × C) was significant ($p < .05$) indicating that training with a material was related to acquisition of conservation with the material.

*Training*

Table 3 shows that there were significant differences between groups on training at Juice Level 1 ($p < .01$), Juice Level 2 ($p < .10$), and Juice Level 3 ($p < .05$). Scheffé's test for comparison of means indicates a significant difference ($p < .05$) between the Retarded group and the other two groups at all three juice training levels. At Juice Level 3 the Gifted group made significantly fewer training errors than the Normal group.

TABLE 3.—Analysis of variance for group differences in errors during training at each level

| Training Level | Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Juice | | | | | |
| Level 1 ($N$ = 37; 26; 33)[a] | Between | 2 | 2.58 | 4.99 | <.01 |
| | Within | 93 | 0.52 | | |
| Level 2 ($N$ = 35; 24; 27)[a] | Between | 2 | 6.63 | 2.67 | <.10 |
| | Within | 83 | 2.49 | | |
| Level 3 ($N$ = 31; 23; 26)[a] | Between | 2 | 19.30 | 3.68 | <.05 |
| | Within | 77 | 5.24 | | |
| Clay | | | | | |
| Level 1 ($N$ = 31; 20; 24)[a] | Between | 2 | 0.05 | <1 | |
| | Within | 72 | 0.49 | | |
| Level 2 ($N$ = 28; 19; 20)[a] | Between | 2 | 0.48 | <1 | |
| | Within | 64 | 0.49 | | |

[a]The values of $N$ refer to the number of subjects from the Normal, Retarded, and Gifted groups, respectively, who took part in training at each level.

The data were analyzed for differences in training between those subjects in the Normal, Retarded, and Gifted groups who acquired conservation and those who did not. Any subject who made more than one error (that is, failed to give a *same* response) in any material on his final posttest was considered a nonconserver. The minimum number of *same* responses for conservers was six—two on juice, one on

sand, two on clay, and one on paper. Using this criterion, there were 11 normal, 10 retarded, and 16 gifted subjects who acquired conservation. A chi-square analysis of the proportion of those who acquired conservation in each group was not significant.

Table 4 summarized the data on training errors for conservers and nonconservers in the three groups on both sessions of Juice Level 1. As indicated previously, the Retarded group made more training errors at this level, but the insignificant interaction between acquisition and groups indicates that retarded conservers did not differ from retarded nonconservers.

TABLE 4.—Analysis of variance for training errors on both sessions of Juice Level 1 made by conservers and nonconservers in all groups

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Conservers versus nonconservers (A) | 1 | 0.38 | <1 | |
| Groups (B) | 2 | 3.29 | 4.87 | <.01 |
| A × B | 2 | 0.52 | <1 | |
| Error | 91 | 0.68 | | |

The differences in training for the conservers in the Normal, Retarded, and Gifted groups are presented in Table 5. Two separate analyses of variance were done—one on the mean number of training levels needed for activation, the other on the mean number of errors per training level. On both these measures, the differences between groups were not significant.

TABLE 5.—Analysis of variance for number of training levels before conservation and mean errors per training level for normal, retarded, and gifted conservers

| | Source | *df* | *MS* | *F* |
|---|---|---|---|---|
| Training levels | Between | 2 | 0.11 | <1 |
| | Within | 34 | 2.13 | |
| Errors | Between | 2 | 0.15 | <1 |
| | Within | 34 | 0.48 | |

The analysis of training errors for nonconserving subjects is summarized in Table 6. The difference between nonconserving normal, retarded, and gifted

subjects was significant ($p < .01$). Scheffé's test for comparison of means shows that the retarded nonconservers differed significantly from the normal and gifted nonconservers ($p < .05$) in the mean number of errors per training level. The differences between training levels, and the interaction between levels and groups, were also significant ($p < .01$). Figure 2 is a graph of this interaction. It shows the retardates' relative difficulty at Juice Level 3.

TABLE 6.—Analysis of variance for training errors on successive training levels for normal, retarded, and gifted nonconservers

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Groups (A) | 2 | 15.63 | 5.57 | <.01 |
| Error (a) | 56 | 2.80 | | |
| Training levels (B) | 4 | 31.33 | 18.60 | <.01 |
| Error (b) | 224 | 1.68 | | |
| A × B | 8 | 4.72 | 2.80 | <.01 |

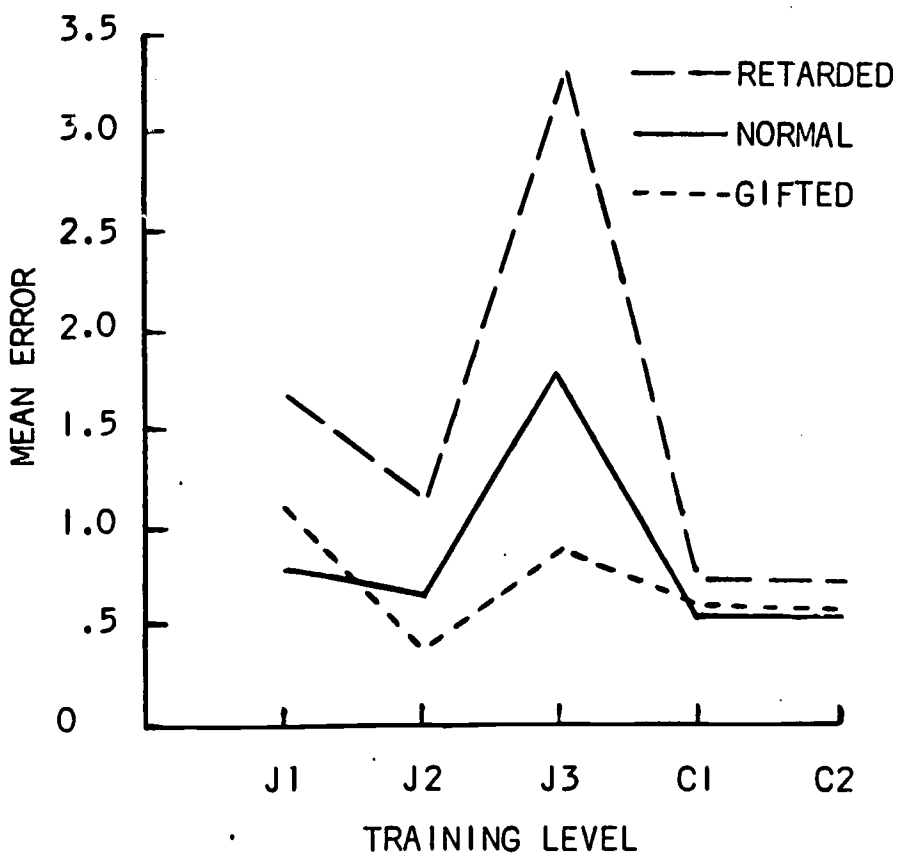



Fig. 2—Mean training errors of normal, retarded, and gifted nonconserving subjects at successive training levels

To summarize the training results, the Retarded group as a whole made significantly more errors before reaching the training criterion than the Normal and

Gifted groups. However, the difference was largely accounted for by the errors made by retarded subjects who did not eventually conserve. Retarded conserving subjects did not differ from normal and gifted conservers except at Juice Level 1.

*Explanations*

The percentage of *same* conservation responses which were accompanied by adequate explanations were computed for both conserving and nonconserving subjects in all three groups. For the conserving subjects, this percentage was calculated for their last posttest—the level at which they acquired conservation—and then separately for all preceding posttests. The results are presented in Tables 7 and 8. The difference between conserving normal, retarded, and gifted subjects on their final posttest was statistically significant at the .10 level. Table 8 shows that conservers gave significantly more adequate responses than nonconservers ($p < .01$) on all posttests which preceded the final posttest where they reached the criterion for conservation. On posttests preceding acquisition, normal, retarded, and gifted conservers did not differ on the percentage of *same* responses accompanied by adequate explanations.

TABLE 7.—Analysis of variance for percentage of *same* responses accompanied by *adequate* explanations on the final conservation posttests for normal, retarded, and gifted conservers

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Between | 2 | 0.37 | 3.08 | <.10 |
| Within | 34 | 0.12 | | |

TABLE 8.—Analysis of variance for percentage of *same* responses accompanied by *adequate* explanations for conservers and nonconservers in the three groups on all posttests before conservation was attained

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Conservers versus nonconservers (A) | 1 | 1.48 | 9.87 | <.01 |
| Groups (B) | 2 | 0.11 | 1 | |
| A × B | 2 | 0.05 | 1 | |
| Error | 34 | 0.15 | | |

*Extinction*

The conserving subjects in the three groups were compared on their scores on the two extinction items. The total score on both extinction questions for conservers in all three groups is presented in Table 9. The analysis of variance for differences between conservers in all three groups is summarized in Table 10. The difference between groups was significant, and a Scheffé test for comparison of means indicated that the Retarded group differed from Normal and Gifted groups ($p < .05$). The extinction questions of four normal conservers and one gifted conserver were unscorable because the examiner did not record the explanations.

TABLE 9.—Distribution of extinction scores for the normal, retarded, and gifted conservers

| Total Extinction Score | Number of Subjects | | |
|---|---|---|---|
| | Normal | Retarded | Gifted |
| 0 | 5 | 4 | 14 |
| 1 | 1 | 3 | 1 |
| 2 | 1 | 3 | 0 |

TABLE 10.—Analysis of variance for total extinction scores for normal, retarded, and gifted conservers

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| Between | 2 | 2.09 | 5.25 | <.05 |
| Within | 29 | 0.39 | | |

A Pearson Product Moment correlation of -0.38 was obtained for the conserving retarded subjects between scores on the explanation measure and resistance to extinction. The explanation measure used in this correlation was the percentage of *same* responses accompanied by adequate explanations on the final posttest taken by the subjects. This slightly negative correlation could not support the expected relationships between correct verbal explanations and resistance to extinction.

*Oscillation*

Three measures of the extent to which members of the groups differed in their oscillations between conservation and nonconservation responses are presented in Table 11. The first measure shows the number of subjects in each group

who gave fewer *same* responses on any posttest than they had on a preceding posttest. In the second measure, all subjects who went from two *same* responses in any one material on one posttest to no *same* responses on any subsequent posttest were regarded as oscillators. The third measure indicates the number of subjects in each group who gave, at least, one *same* response accompanied by an adequate explanation on any one material (juice, sand, clay, or paper) and then failed to give at least one *same* prediction with an adequate explanation on the same material in any subsequent posttest. Chi-square analyses on all three measures of oscillation were not significant.

TABLE 11.—Number of normal, retarded, and gifted subjects who oscillated between conservation and nonconservation responses on three measures of oscillation

| Oscillation Measure | Number of Subjects | | |
|---|---|---|---|
| | Normal | Retarded | Gifted |
| First measure | | | |
| oscillated + | 7 | 7 | 13 |
| oscillated - | 12 | 10 | 14 |
| Second measure | | | |
| oscillated + | 2 | 3 | 1 |
| oscillated - | 11 | 11 | 16 |
| Third measure | | | |
| oscillated + | 0 | 1 | 3 |
| oscillated - | 8 | 6 | 8 |

*DISCUSSION AND CONCLUSIONS*

The amount of training needed to acquire conservation of substance was not related to intelligence level. There also did not appear to be a relationship between intelligence level and directness of training needed before conservation was acquired. The data in Table 2 indicate that the three groups did not differ in ability to generalize to other materials. The three groups showed no difference in their tendency to oscillate between conservation and nonconservation as would have been predicted by Inhelder (1966).

The main differences between groups were on errors during training, extinction, and explanations. On errors during training, those retardates who eventually conserved did not differ from their conserving counterparts in the Gifted and Normal groups except at Juice Level 1. At this level, the performance of individuals was probably influenced more by group performance than at other levels. The difference on training errors between groups was largely accounted for by those retarded subjects who did not conserve.

The difference between groups on the extinction item was related to intelligence level. This indicated that retarded subjects were more susceptible to conflicting evidence, and their acquired concept was not as stable as in the Normal and Gifted groups. It should be noted that seven out of ten retarded conservers resisted at least once on the two extinction items, four of them resisted twice. The level of extinction was not high.

The normal, retarded, and gifted conservers differed at the .10 level on the percentage of *same* predictions accompanied by adequate explanations on the last posttest. The ability to produce explanations was not related to extinction, in fact there was a slightly negative relationship. Thus the level of explanations does not guarantee resistance to extinction.

## *SUMMARY*

The major interest of this study centered around the manner in which children of different IQ levels acquire and apply new concepts. Earlier studies had failed to disclose consistent differences. Conservation of substance tasks were used in order to rule out, as much as possible, the effects of prior substantive knowledge on acquisition and transfer of new learning. A cyclical schedule of testing and training phases was employed to reveal possible effects that would not be revealed in a simple test-treatment-retest design. Nevertheless, the results of this study confirmed earlier studies in failing to show any notable differences between IQ groups. Retarded subjects did make more errors in training than normal and gifted subjects, but this could have been expected from the slower rate of learning which is, in essence, the defining characteristic of mental retardation. Aside from this difference, the groups were equivalent in the attainment of conserving responses and transfer to new materials.

There was some evidence, although rather weak, that retardates were more susceptible to extinction of conservation responses. This difference, if it has generality, could have profound implications for the growth of logical thinking, even if the difference is slight. Logical thinking depends not on the appreciation of what is empirically probable, but on the appreciation of necessity, sufficiency, and admissibility. If retardates come out of learning experiences with empirical hypotheses and normal children come out of them with logical certainties, the difference may not be immediately visible in their performance. It may, however, make a great deal of difference in what the child has to build on and work with in subsequent learning situations. This aspect of intellectual differentiation appears worthy of additional study. On the other hand, the present investigation, considered in relation to other studies which have yielded similarly negative results, does not lend encouragement to further study of the relation between general intelligence level and intuitive concept formation.

*BIBLIOGRAPHY*

Blackman, L. S., and Heintz, P. The mentally retarded. *Rev. Educ. Res.*, 1966, 36, 5-36.

Brison, D. W. "Acquisition of conservation of substance in a group situation." Unpublished doctoral dissertation, University of Illinois, 1965.

Brison, D. W. Acceleration of conservation of substance. *J. genet. Psychol.*, 1966, 109, 311-322.

Flavell, J. H. *The developmental psychology of Jean Piaget.* Princeton, N.J.: Van Nostrand, 1963.

Gallagher, J. J. *Analysis of research on the education of gifted children.* Springfield, Ill.: Office of the Superintendent of Public Instruction, 1961.

Inhelder, Bärbel. *The diagnosis of reasoning in the retarded.* Translated by Will Beth Stephens. New York: John Day, 1966.

Johnson, G. O. *Comparative studies of some learning characteristics in mentally retarded and normal children of the same mental age.* Syracuse, N.Y.: Syracuse University Research Institute, 1958.

Johnson, G. O., and Black, K. A. *Learning performance of retarded and normal children.* Syracuse, N.Y.: Syracuse University Press, 1960.

Piaget, J., and Inhelder, Bärbel. *Le développement des quantités chez l'enfant.* Neuchâtel: Delachaux et Niestlé, 1941.

Rosenberg, S. Problem solving and conceptual behavior. *Handbook of Mental Deficiency.* Edited by N. R. Ellis. New York: McGraw-Hill, 1963.

Smedslund, J. The acquisition of conservation of substance and weight in children: III. Extinction of conservation of weight acquired "normally" and by means of empirical controls on a balance. *Scand. J. Psychol.*, 1961, 2, 85-87.

Sullivan, E. V. "Activation of conservation of substance through filmed modeling techniques." Unpublished doctoral dissertation, Syracuse University, 1966.

Wallace, J. G. Concept growth and the education of the child. Sussex: National Foundation for Educational Research in England and Wales, 1965.

Wallach, M. A. Research on children's thinking. *Child Psychology.* Edited by H. W. Stevenson. Sixty-second Yearbook of the National Society for the Study of Education, Part I. Chicago: National Society for the Study of Education, 1963.

Woodward, Mary. The application of Piaget's theory to research in mental deficiency. *Handbook of Mental Deficiency.* Edited by N. R. Ellis. New York: Mcgraw-Hill, 1963.