KLING-J. KENNETH: The Relevance of an Adequate Concept of "Bigger" for the Investigation of Size Conservation: A Methodological Critique. (1968) Directed by: Dr. Ernest Lumsden.

The hypothesis examined by the present experiment was "that a multi-dimensional concept of 'bigger' is a necessary, but not sufficient, condition for a child to evidence size conservation." To assure that a sufficient number of children had an adequate concept of "bigger", in order to permit a test of this hypothesis, half of the Ss to be tested received training explicitly designed to this end. The other half received training in an object recognition problem, a task irrelevant to an adequate concept of "bigger." All Ss were then tested for size conservation and weight conservation. In addition, to provide some knowledge of the concept of "bigger" for the control Ss, these Ss were assessed in this regard as well.

Because there is strong evidence in the literature to suggest that size conservation is related to age, the Ss were divided into two groups on that basis: five and one-half to six and one-half years and six and one-half to seven and one-half years, with 20 Ss in each group. The Fisher Exact probability test analysis revealed a statistically significant difference between the experimental and control groups in regard to an adequate concept of "bigger" for both age groups, with the experimental groups evidencing the concept. In the older age group, the experimental Ss evidenced size conservation significantly more frequently than did the control group. The failure to find a significant difference between the experimental and control groups in regard to size conservation for the younger group is not inconsistent with the hypothesis inasmuch as an adequate concept of "bigger" is maintained as only a necessary, not an adequate, condition for evidencing size conservation. Furthermore, this

finding is consistent with the notion that size conservation is related to age.

Unlike Piaget's findings, the data obtained in this experiment indicate that weight conservation appears at an earlier age than size conservation. It is pointed out, however, that this study is not the only one incongruent with Piaget in this matter.

In the final analysis, the results of this experiment suggest that data previously obtained with respect to the development of size conservation are confounded with the propaedeutic development of an adequate concept of "bigger."

THE RELEVANCE OF AN ADEQUATE CONCEPT OF "BIGGER" FOR THE INVESTIGATION OF SIZE CONSERVATION. A METHODOLOGICAL CRITIQUE

by

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INTRODUCTION

In recent years there has been much investigation of the phenomenon of conservation of substance, volume, or size (Braine and Shanks, 1965; Brison, 1966; Hunt, 1961; Lovell, 1965; Piaget, 1960; and Smedslund 1961). This phenomenon is manifest by perceptual invariance of mass under transformation of form. The classical test for the study of size conservation employs pieces of plasticine or modeling clay. The child is presented with two equal amounts of the material which are both similarly shaped (balls, blocks, etc.) and told that they are the same size. Then, in full view of the child, one of the objects is elongated into another shape, at which point the experimenter asks the subject, "Is one bigger than the other?" After the child answers, he is asked why he gave his particular answer. A conservation response would be to the effect that the two objects are still the same size because they were the same size initially; or that they must be equal-sized since nothing was added or subtracted during the deformation; or that they are the same size since only the shape of one was changed. All of these responses reflect the notion that volume is conserved across transformation of shape. Children who have not attained this level of cognitive development will generally make their judgments on the basis of apparent, phenomonological aspects of the objects, saying that one is "bigger" because it is "longer" or "taller."

Piaget & Inhelder, the pioneers in this field of inquiry, have reported (Smedslund, 1961) that conservation of substance appears, on the average, between seven and eight years of age. Research effort has more recently been directed to a more definitive analysis of the period prior to the appearance of unequivocal evidence of conservation of size when Piaget asserts that the "perceptual" characteristics determine judgment

(Smedslund, 1961). In one of these studies, Braine and Shanks (1965) determined that (1) by about five years of age a majority of children are capable of a distinction between real and apparent size, and (2) children under seven tend to construe questions containing the word "bigger" as questions about phenomenal or apparent size unless feedback information forces a "reality" interpretation. The suggestion here was that the Piagetian method of size conservation investigation was ambiguous because it employed questions which allowed the subjects to make phenomenal judgments which were confounding the results reported. Braine and Shanks concluded, therefore, that "the early stages of development are not amenable to study by Piagetian procedures which do not elicit the processes under investigation in the younger subjects." It will be seen that the present investigation tests a hypothesis related to the conclusion of Braine and Shanks. The thesis expounded will be differentiated from theirs in the discussion section.

Before discussing points specifically concerned with this investigation it is probably advisable to consider more closely the basic elements underlying conservation of substance. In Baldwin's (1967) treatment of "The Theory of Jean Piaget" is a discussion of "invariance" which takes into account the problem at hand. Of importance here is the distinction made between perception and thinking. Thinking is said to bring evidence from past experience to bear on immediate problems, whereas perception is limited to data more or less available at the moment with no pertinent information available from the past. If this is a useful distinction, there must be a certain point in the child's chronological development where he advances from the singular use of naive perception to a more veridical level by way of thinking or reason. Attainment of the ability to think and reason, however, apparently does not provide a child with the capacity for conservation of size. Piaget hypothesized that four factors cause a child in the preoperational period (Piaget's term for the period of years, two to seven, during which the child's internal cognitive picture of the external world is gradually growing) to fail invariance or conservation tests. First, failure to integrate temporally separate events, i.e., in the classical test for conservation of size using plasticine cubes, the child is unable to use the evidence from the initial situation in which the experimenter has stated that the cubes were equal. Instead, he apparently searches the immediate situation, after the deformation of one cube, for the answer, oblivious to the foregoing evidence of equality. Second, lack of reversibility of his schemas (Piaget's term for structural elements of behavior); specifically, when the child fails to realize that the deformed cube can be reshaped to its original form he has difficulty in solving the problem. Third, failure to realize that a change in the form of the substance does not in any way alter its quantity. In the case in point, a child must realize that the deformation of the plasticine does not either add or subtract any plasticine from the amount originally contained in the cube. Fourth, failure to realize that if nothing is added or removed from the cube its total size remains constant. Such a realization seems obvious to the average adult; however, an inexperienced child evidently finds difficulty reaching such a conclusion. In the final analysis, before a child can grasp the concept of conservation of size, he must be able to reconcile the appearance of the blocks of clay with the characteristics of the material which conjunctively indicate that the blocks are equal. Thus, a child must realize that increased height and decreased width are compensating changes. This alone, however, is not a sufficient realization to qualify as an exemplification of the concept of conservation of size. For example, instances often occur wherein a child may answer that both blocks, the cube and its transformed mate, are the same size and in response to "Why?" says something to the effect that "although the one you changed is taller, it is still skinny, so, they are the same size." Such a response indicates that the child apparently has a multi-dimensional concept of "bigger", but has not demonstrated conservation. The child has only recognized that the blocks of clay are equal without acknowledging the necessity that they must be equal since it was given that they were equal before the simple transformation of shape. He should, therefore, be asked a second question: "Can you think of any other reason for knowing that they are the same size?" Unless he now says something about the fact that they were equal before the experimenter changed the shape or that changing shape doesn't change size, etc., he should be considered as having a good concept of "bigger", yet not exhibiting size conservation. What is needed, therefore, is conceptualization of the four pertinent factors discussed above before an adequate concept of conservation of substance can be realized.

After the mechanics of the concept of conservation of size have been established, as they seem to have been by Piaget's factors, another question arises. The question is whether or not a child of seven and one-half and younger applies the same meaning to the descriptive adjectives used in typical conservation tests as an adult would, so that he is truly cognizant of what the experimenter means when he says "equal", "bigger", "taller", etc. Evidence exists that would render a negative answer to this question. Lumsden and Poteat (1968) addressed an investigation to the nature of the concept of "bigger" in five and six year old children in which they employed a series of paired planimetric geometric figures, equal in area, but of different vertical and horizontal dimensions. Their data were unequivocal in pointing to the salience of the vertical dimension in the concept of "bigger" for this age group. It was suggested that this inadequate concept is a confounding factor in any determination of the concept of conservation of size in which the question asked is: "Is one bigger than the other?" An unpublished study by Hulsebus and Clifton (1968) extended the research to three-dimensional geometric objects. Hulsebus and Clifton found that with three-dimensional objects of equal volume the vertical dimension significantly influenced the judgment of "bigger" of five-and six-year olds. Even when the object having the greater vertical dimension was only 92% as voluminous as the less vertical object, it was always chosen as the "bigger" object.

These recent studies point to the necessity of investigating the role of the concept of "bigger" in the typical size conservation study. It is obvious that in the previous Piagetian-type investigations of conservation of size an inadequate concept of "bigger" could have been a confounding factor having the effect of delaying the age at which size conservation can be evidenced. In the circumstance of considering "bigger" to mean "taller", a child would construe an altered block of clay, changed to be twice as tall as its original twin, as being "bigger." Therefore, it is only when the experimenter is positive that the child has a volumetric (multi-dimensional) concept of "bigger" that he can consider the child's responses as a valid basis for revealing the concept of conservation of size. Only when a child has demonstrated the possession of a concept of "bigger" that is consistent with the adult concept and then reports the modified block as "bigger" can it be safely said that the child lacks size conservation. With no independent evidence regarding his concept of "bigger" it is impossible to determine how the subject interprets the conservation question.

In order to investigate the possible dependence of valid size conservation data upon an adequate concept of "bigger" it obviously becomes necessary to develop an adequate concept in some of these children. It was thought that this could be achieved by approaching the most difficult instance of different shaped objects of equal volumes by small successive approximations with feedback. The intention here was to develop a multi-dimensional concept of "bigger" as a means of insuring that the subject interprets the question as one involving volume.

The position taken is that it is untenable to expect to disclose size conservation in a child until he has attained an adequate concept of "bigger", the critical word in the question to which he must respond. If this stage of semantic development lags behind the concept of conservation in the child the consequences will be a delay in the age at which size conservation can be evidenced in response to the question, "Is one bigger than the other?" The specific hypothesis, therefore, is that a multi-dimensional concept of "bigger" is a necessary, but not sufficient, condition for a child to evidence size conservation in response to the question of "Is one bigger than the other?" Supporting data for this hypothesis would be that only those subjects with an adequate concept of "bigger" give evidence of size conservation. It seemed that a reasonable test of the hypothesis would be to train some subjects to an adequate concept of "bigger" and not train others and then compare the relative incidence of size conservation in the two groups. Under such conditions it would be expected that the data of the control group would permit some knowledge regarding the normal development of an adequate concept of "bigger" relative to the development of size conservation. Further experimental procedures to be described in the next chapter provided a check on the relative ontogenetic development of conservation of weight and conservation of size, as well as a check on the possible unintended effects of the treatment upon the presumedly irrelevant concept of weight conservation.

METHOD

Subjects

The Ss were 20 pupils from Friendly Avenue Baptist Church Kindergarten and 20 first-grade students from Curry Elementary School, both facilities being located in Greensboro, North Carolina. The age of the kindergarten Ss ranged from approximately five and one-half to six and one-half years, and the age range of the first-grade Ss was from approximately six and one-half years to seven and one-half years. Boys and girls within each age group were randomly assigned to the experimental and control groups with the restriction that an equal number of Ss of each sex were assigned to each group. Under the conditions of S-assignment and S-availability, there were four boys and six girls in both the experimental and control groups in the older age range and five boys and five girls in both the experimental and control groups in the younger age range.

Apparatus

Nineteen wooden blocks were constructed, painted gray, and used in an attempt to expedite experimentally the development of an adequate concept of "bigger." The volume of these blocks ranged from about two to thirty-six cubic inches; their specific dimensions are indicated in Appendix A.

The pairs of blocks were presented to Ss individually. Appendix B contains a copy of the schedule of paired-block presentations. The objects were presented on a turn-table in the apparatus pictured in Appendix C. The turn-table was mounted and operated in such a manner as to give full object exposure to S, who was seated at the front of the apparatus. A remote-controlled door allowed E to exchange objects on the turn-table without being observed. S returned his choice of the "bigger" object to

E through a curtained hole in the left front surface of the apparatus (see Appendix C).

The turn-table was electrically controlled by an automatic timer which allowed it to make one-half of a revolution before stopping. This exposure lasted approximately 14 seconds, and the timer automatically reset itself for the next trial. The stimulus presentation schedule provided for each pair of objects being presented twice; when the pair appeared again, laterality was reversed.

Another group of wooden blocks, six in number, painted white, and all of equal height and volume (see Appendix D), was used to provide the control Ss with a training period on a different task of approximately the same duration as the training the experimental group received. This task did not involve the concept of height or size, but was an object constancy task. In this manner the control Ss had a comparable amount of experience with E prior to the critical conservation examination.

A tachistoscope, Model V-0959, produced by Polymetric Products (see Appendix C), was used to present each of the above described objects. The background panel at the rear of the apparatus was removed and a wooden platform, painted black, was inserted to provide a display base for the objects. A black cardboard swinging door was affixed to the opening where the objects were inserted to provide a homogeneous background for the objects. S viewed the objects through a viewing tunnel located in the front of the tachistoscope. Exposure time was controlled by means of a time exposure setting built into the apparatus.

Another instrument, the "penny dispenser device" (see Appendix C), provided a means of rewarding both control and experimental Ss for correct responses and "punishing" them for incorrect responses. "Punishment" consisted of withdrawing a penny from those accrued at the time of the incorrect response. The apparatus consisted of a wooden box, painted black, embodying a plexiglass window at the front which allowed S to view pennies as they were dispensed by E and descended down a zig-zagged track to the bottom where they accrued until the end of training for each S. However, the apparatus also allowed for E to withdraw a penny whenever S made a mistake. In this manner, E was able to reward and punish S appropriately without having to risk the unpredictable consequences of money exchange with the child, and at the same time allowed S to see how many pennies he had "won" at any point in the training session.

Procedure

Prior to any testing, E introduced himself to each class as a whole and offered a brief explanation of why he was there, indicating that he wanted to play a game with the children and that they could "win" pennies for their participation. This preliminary interaction between E and each entire age group of Ss was used as a method of reducing any anxiety an individual S might bring to the testing session and to promote as much rapport as possible between E and Ss.

The experimental treatment administered to each S consisted of two stages. Stage one was a training session in the three-dimensional concept of "bigger" for experimental Ss and a period of equivalent exposure to E for control Ss, in which a measure of S's recognition of object constancy was taken. The second stage, a traditional measure of each S's conservation of size and weight, was the same for both experimental and control Ss.

The training session for the experimental Ss consisted of training in the three-dimensional concept of "bigger" by means of a programmed random presentation of two-block combinations drawn from a pool of various sized three-dimensional wooden blocks (see Appendix A) and presented by means of an object presentation apparatus. At the beginning of the training session for the experimental Ss, S was seated in a chair at the table facing both the object-presentation apparatus and the money-dispenser apparatus. At this point there were no pennies visible in the track of the money dispenser and the door of the object-presentation apparatus housing the turn-table was closed. After S was comfortably seated and sufficiently attentive, E read the following instructions:

> We are now going to play a game with wooden blocks. When I open the door (E points to the sliding door in the object presentation apparatus) you will see two blocks going around very slowly on a table like a record player. When they stop going around, I want you to pick up the bigger wooden block and push it through the hole in the box (E points to the hole in the front of the object presentation apparatus). When a person is talking about wooden blocks, "bigger" means the block that has the most wood in it. The "bigger" wooden block will not always be the "taller" block. It will not always be the "fatter" block. Sometimes the "bigger" block will be "taller," sometimes it will be "shorter," but always the "bigger" block is the one with the most wood in it. That's what "bigger" means when we're talking about wooden blocks.

A this point in the instructions, E called S's attention to the money dispenser apparatus by saying:

> Every time you are right and give me the block that is really the "bigger" one, you will "win" a penny (E activates dispenser lever and penny rolls down track)...every time you are right you get a penny (E activates dispenser lever again)...But every time you are wrong you lose a penny (E activates the subtraction lever and a penny disappears from S's view)...every time you're wrong you lose a penny (E activates subtraction lever again).

The two-block combinations were presented in phases according to the volumetric ratio of the pairs (see Appendices A and B). The ratios of the volumes were: Phase I, 1:3; Phase II, 1:2; Phase III, 2:3; and Phase

IV, 2:3 and equal. Phase I was composed of six two-block combinations, two of the combinations being repeated for a total of eight pairs. These eight pairs were presented twice, both times in a different random sequence and with laterality reversed. Phases II and III were composed of four basic block combinations and each combination was programmed to be presented to S in two different dimensional orientations, thus making eight pairs. The eight pairs were presented in two different randomized sequences, thus providing 16 trials in each of these two phases, also. Phase IV was composed of a program of 13 pairs of blocks, six pairs having a volumetric ratio of 2:3 randomly interspersed among seven pairs of blocks that were equal in volume, but which were of different vertical dimensions. It was planned that if any S failed to achieve the criterion of performance for Phase I, II, or III before the 16 trials had been exhausted, then E was to begin again, presenting block combinations in the original order of that phase, until the criterion was attained or the arbitrary stopping point was reached (since all Ss did reach criteria within the 16 prescribed trials it did not become necessary to eliminate any Ss from any group). The criteria of performance for the first three phases were as follows: Phase I, seven correct trials of the last eight trials administered; Phase II, six correct trials of the last eight trials administered; and Phase III, six correct trials of the last eight trials administered. Criterion performance was reduced from phase to phase due to the increase in similarity of the pairs. The fourth phase was administered to S if the criteria for the first three phases had been met. S was to be eliminated from the experiment if he failed to meet the criteria for the first three phases within the following limits: 16 pairs in Phase I, 20 pairs in Phase II, and 24 pairs in Phase III. It was felt that this many trials with feedback would provide ample opportunity to learn for those Ss who were very inadequate in regard to their concept of "bigger." A pilot study with five children in a comparable age group had reinforced this supposition.

The fourth phase was a training phase which was designed to provide experience with pairs of blocks of equal volume, but different shape. The phase began with the presentation of a block pair in which the two blocks were of equal volume and shape, and it successively approached a combination of equal-sized blocks in which one was twice as tall as the other. In order to insure an emphasis on the concept of "bigger" and its relationship to the concepts of tallness, wideness, and equality, block combinations have a size ratio of 2:3 were randomly interspersed among the equal sized combinations. This phase did not have a performance criterion requirement. Instructions to the S for Phase IV are presented in Appendix E.

It should be pointed out that the critical difference between the conservation test and the equal-volumed block trials of Phase IV was that, in the conservation test, S had a crucial additional reason for knowing that the volumes of the blocks were equal. That is, S saw the questionable object, the taller one, changed from a shape of specified equal size to its altered shape. Thus, the notion of conservation of size, if S had acquired it, should have permitted a conclusion consistent with his multi-dimensional concept of "bigger."

When S made an incorrect choice during the first three phases, E immediately pointed to the dimensional relationships on which the judgment should have been based. The explanations were read from a prepared list of statements appropriate to any response to each pair of blocks (see Appendix F). This list was compiled to assure that instructions were standard for all Ss. All E had to do was to choose the appropriate explanation to fit the type of choice that S had made. E made a conscious attempt to insure that every S received equivalent instruction to the point of attempting to give the explanations in the same tone of voice every time.

Ss who were placed in the control group received, instead of the training session administered to the experimental group, a training period on a different task also involving objects and requiring approximately the same amount of time. The objects used with the control group, unlike those employed in the training of the experimental group, were all of equal height and volume. These objects differed in form only, thus the control Ss were not at all concerned with the concept of size nor with which of the objects were taller.

The objects were presented to the control Ss by means of the tachistoscope (see Appendix C). S was first read the instructions given in Appendix G. He was then presented with a standard object for 10 seconds and told that every time he saw an object in tachistoscopic exposure (.20 seconds) which he recognized to be the standard object, he was to say "Yes", and if he thought it was not the same object he was to say "No". Ss were rewarded and punished appropriately by E for correct and incorrect responses as was the procedure with the experimental Ss. This object-recognition task, therefore, provided rewards and punishment of the same type as the experimental session task, plus an equivalent amount of exposure to E.

In comparison, therefore, both the experimental and control training sessions were alike in the types of reward and punishment appropriately administered to Ss for correct and incorrect responses. Every time an S in either group made a correct response on his particular test he received verbal reinforcement form E, monetary reward in the from of a penny, and the visual stimulation of seeing the penny roll down the track. Similarly, every incorrect response on the part of an S in either group brought about his immediate punishment by having one of his previously "won" pennies disappear instantly into the apparatus. Also, instead of receiving praise from E, experimental Ss were given an explanation of why their response was incorrect, followed on the next correct trial response by a similar explanation of why that response was correct (see Appendix F), and control Ss were simply told that they were incorrect. In effect, the similar treatment of Ss in both the experimental and control groups in regard to reward and punishment minimized the opportunity of introducing confounding variables. Also, the similar treatment of both groups served to insure that all Ss who took the conservation of size test had been exposed to E for approximately the same length of time and in approximately the same way.

It was desirable to have knowledge concerning the concept of "bigger" of the control Ss as well as the experimental Ss who received the training. It seemed judicious, however, to test the concept after the size-conservation test lest attention be called to verticality. Therefore, a test was administered to the control group for the purpose of testing S's concept of "bigger" as a means of obtaining data from this group that could be compared to similar data from the experimental group.

For this purpose combination 3-E, the fifth combination in Phase III, was chosen to be administered to the members of the control group immediately after they had been tested for conservation of size and conservation of weight. Comparable information for experimental Ss was taken from the same combination extracted from the training session data sheet. This particular two-block combination was composed of block number two with its two inch dimension standing vertically and block number four with its three inch dimension oriented vertically (see Appendix A). This particular choice of blocks provided a combination in which there was a 2:3 ratio in height with the shorter block being the "bigger." It was theorized that such characteristics should certainly provide a valid indication of S's concept of "bigger," provided that percautions were taken to insure that S was serious and fully aware of what was being asked of him. In the case of the experimental Ss, the test was administered as a regular part of the training session without any special emphasis. In fact, the evaluation of the experimental Ss' performance on this combination usually was not tabulated until after all testing had been completed for any one day. For the control Ss the test was administered to each S by means of the object-presentation apparatus in the same manner that the block pairs were presented to the experimental S in the training session, but only after the tests of conservation of size and weight had been completed. Again, this was done so as not to inadvertently provide the control Ss with any information that might have an influence on their performance on the test for conservation of size. In this case no special instructions were given the Ss; they were simply asked: "Is one "bigger" than the other?"

The critical measure of the experiment consisted of a traditional measure for determining if S possessed the concept of conservation of size or substance. It was administered to both the experimental and control Ss. The test consisted of E first showing S two cubes of plasticine or modeling clay which were equal in size, as determined by weight measurement, and telling S that they were the same size. Then, with S looking on, E transformed the shape of one of the clay cubes into an elongated rectilinear three-dimensional object twice the height of the remaining cube, placed it on the turn-table with the longest dimension vertically oriented, revolved the turn-table one-half revolution, and asked S pertinent questions about the size of the two objects. (It will be recalled that Phase IV, in which some pairs of equal volume were utilized, was an attempt to break any set for expecting one member of each pair to always be "bigger" than the other. Such a set should not exist in the control group; therefore, Phase IV presumably rendered the two groups more comparable in regard to expectancies for the conservation test than would otherwise have been the case.) At this point the following instructions were read by E:

> I have two cubes of clay here that are exactly the same size, exactly the same size. Now I am going to change the shape of this one (E chose one of the cubes of clay and transformed its shape)...Now, is one bigger than the other?"

If S answered "Yes", or "No" to the question "Is one bigger than the other?," then E asked "Why?" The responses to each of these questions were recorded by E on individual data sheets for each S.

The same procedure was followed by E using two identical blocks of clay and asking S questions concerned with the weights of the objects that were similar in form to the questions concerning size. It was felt that this test of weight conservation allowed a determination of whether or not there were any inconsistencies for S across transformation in shape.

RESULTS AND DISCUSSION

Figure I permits a comparison of the mean number of trials in the training session required by each age group to attain the criterion of each phase. This figure suggests that, as a group, the older children attained the criterion of each training phase with fewer trials than did the younger children. Although the difference in trials to criterion between the two age groups does seems to increase with the difficult discriminations required in Phases II and III, none of the differences is statistically significant (the corresponding t-values are .375, 1.242, and 2.008, with 8 df).

The Fisher Exact Probability test (Hayes, 1963) was used to analyze the post-test data of the experimental and control groups for both age groups. Table 1 shows the comparisons that were made and gives the probability that such frequencies could occur by chance. The minimum acceptable level for significance was .01.

The results indicate that for both age groups there was a significant difference between the experimental and control groups in regard to the development of an adequate concept of "bigger." The experimental group evidenced an adequate concept of "bigger" while the control group did not. This difference in performance is attributed to the training in the concept of "bigger" that was administered to the experimental group, but not administered to the control group. The data indicate that an adequate concept of "bigger" can be taught to Ss of these ages, inasmuch as 100% of the older trained Ss (experimental) evidenced an adequate concept as opposed to only 40% of the untrained Ss (control)

FIGURE I

TRIALS TO CRITERION FOR EACH PHASE BY AGE GROUP

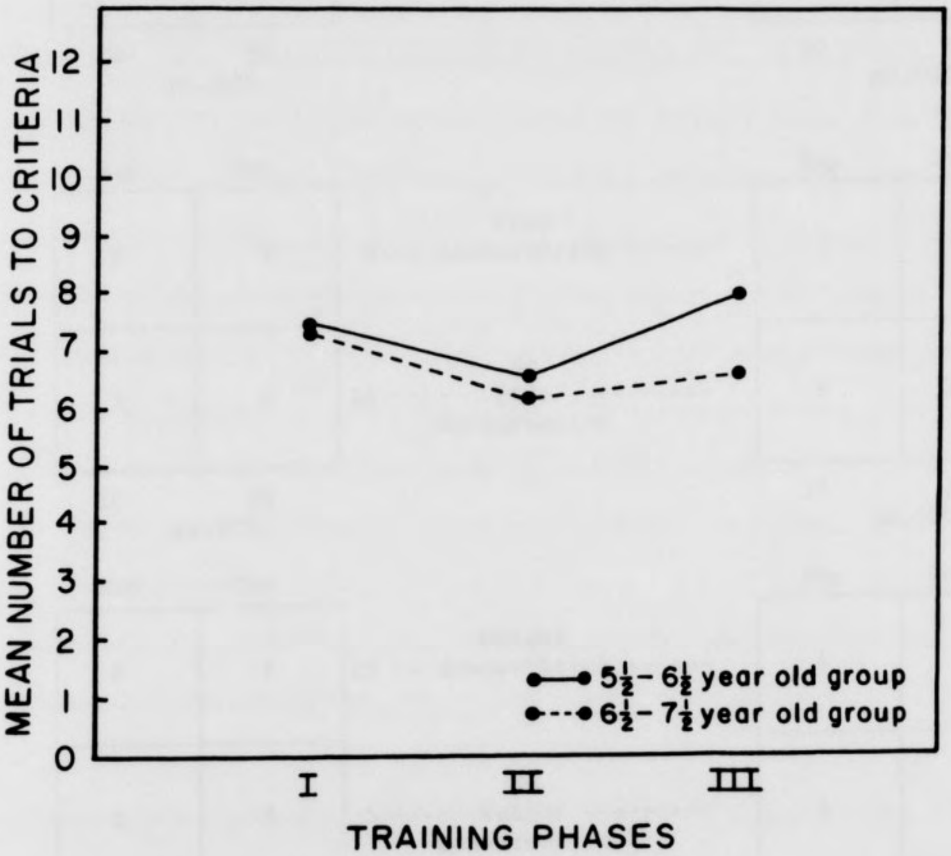


TABLE 1

DATA FREQUENCY TABLES

	6½ to 7½ Age Group: Exp*	6½ to 7½ Age Group: Con**	Total		5½ to 6½ Age Group: Exp	5½ to 6½ Age Group: Con	Total
Adequate Concept of Bigger	10	4	14		9	4	13
Inadequate Concept of Bigger	0	6	6		1	6	7
Total	10	10			10	10	
	p≤.005				p≤.003		
Size Conservation	7	1	8		1	0	1
No Size Conservation	3	9	12		9	10	19
Total	10	10			10	10	
	p≤.009				p≤.500		
Weight Conservation	8	7	15		4	5	9
No Weight Conservation	2	3	5		6	5	11
Total	10	10			10	10	
	p≤.348				p≤.315		

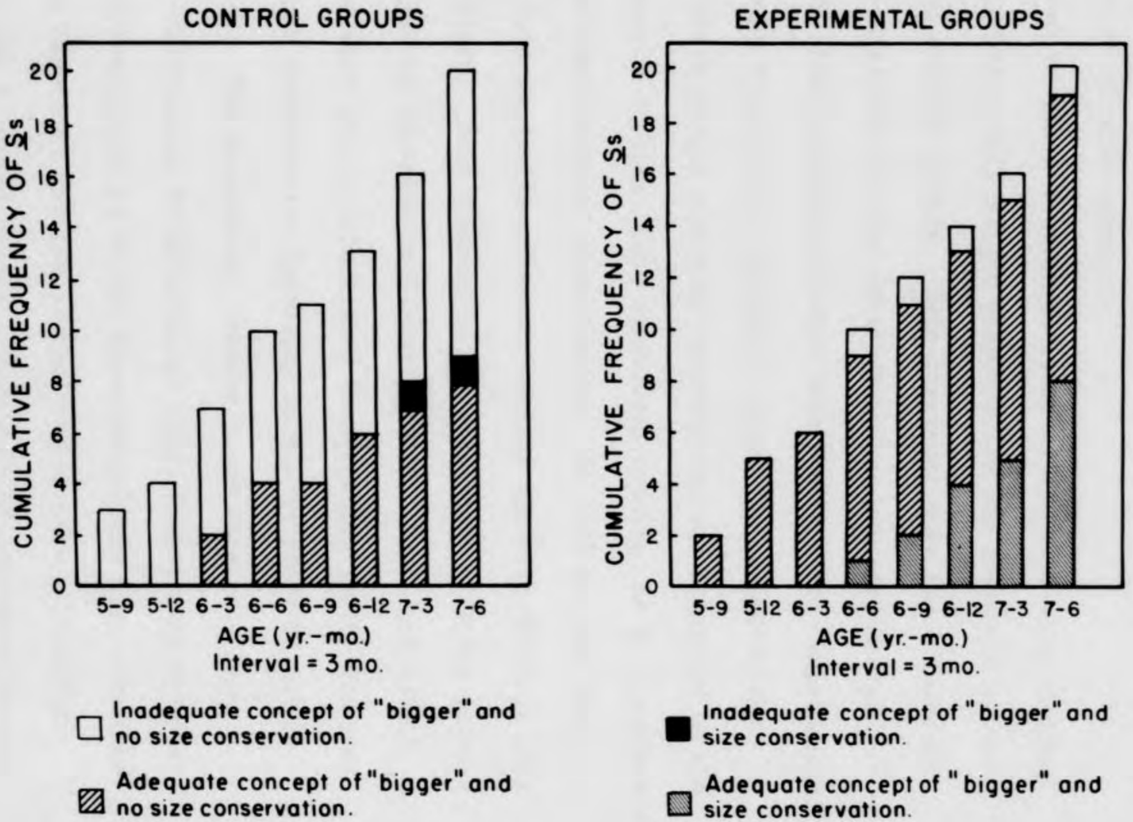
* Exp----denotes Experimental Group
** Con----denotes Control Group

who must have attained this concept naturally. Since experimenters of the Piagetian tradition have not trained their Ss in the concept of "bigger" it is reasonable to assume that the control Ss tested in this investigation and the Piagetian Ss are similar. Thus, it would seem likely that many of Piaget's Ss did not have an adequate concept of "bigger" and, therefore, provided data yielding an age for the appearance of size conservation greater than may actually be the case.

Considering the comparisons on the size-conservation test, it is seen that the experimental Ss of only the older group significantly differed in regard to conservation of size from the control group. No significant difference was obtained with the younger group (see Table 1). At this point we should acknowledge that the younger group was not drawn from the same school population as the older group. It is, of course, impossible to assess the relevance of this fact for the different frequencies with which size conservation was evidenced between the two age groups. Figure 2 contains cumulative frequency graphs for both the experimental and control groups across age levels which have been divided into three month increments. An inspection of these graphs reveals a striking difference between the two groups in regard to the relative cumulative proportion of Ss at each successive age level who evidence an adequate concept of "bigger." The graphs also portray the difference in the relative occurrence of size conservation. It should be noted that in the experimental group size conservation is evidenced before the age of six and one-half years and continues to be evidenced at each successive age level thereafter. The singular instance of conservation in the control group, however, appears beyond the age of seven years. Although these data

FIGURE 2

CUMULATIVE FREQUENCY OF Ss EVIDENCING RESPECTIVE CONCEPTS FOR SIZE CONSERVATION WITH INCREASING AGE.



do unequivocally indicate that size conservation will be made manifest at an earlier age if the Ss possess an adequage concept of "bigger", they do not permit specification, with any generality, of the age at which conservation of size appears.

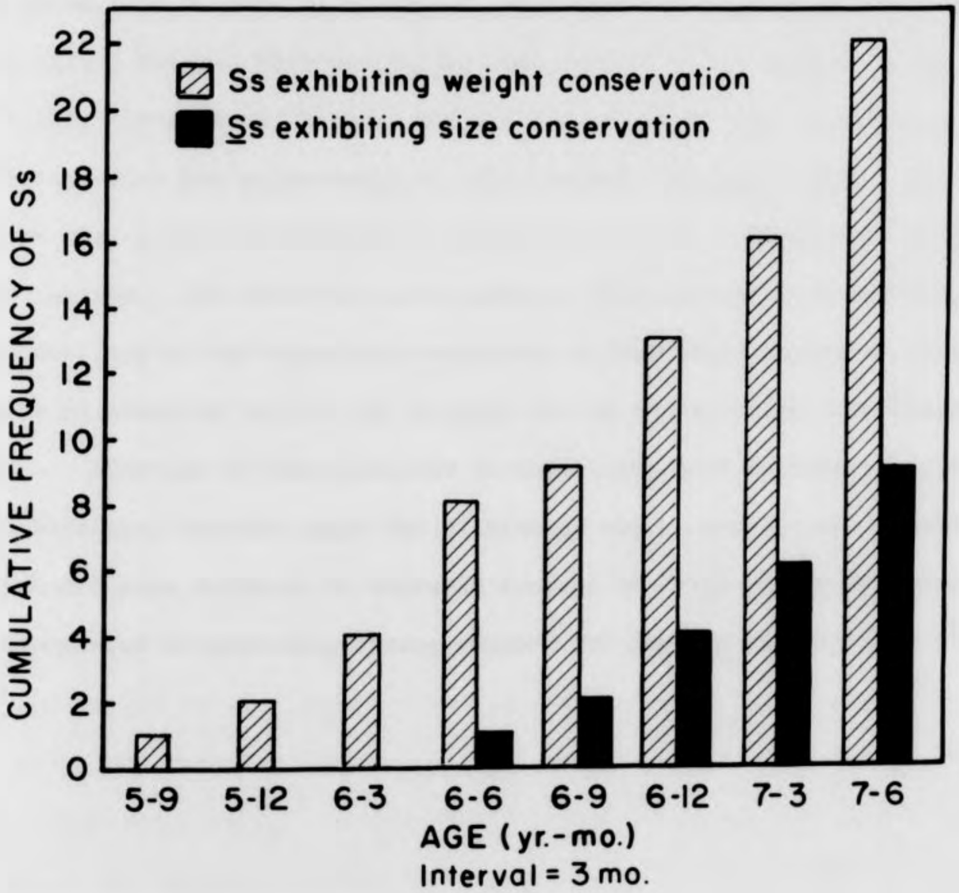
As indicated in Table 1 no significant differences were attained in the frequency with which weight conservation was evidenced between experimental and control groups. This indicates that the effects of training were restricted to size conservation as was anticipated. These weight and size conservation data were pooled across experimental and control groups to provide a realistic basis for comparing the frequency with which weight and size conservation was evidenced by the Ss tested. Figure 3 depicts this comparison showing the Ss distributed according to age increments of three months. It will be seen that weight conservation is manifested at an earlier age with these Ss than is size conservation. This finding is not consistent with the general findings of Piaget as reported in Flavell (1963). Smedslund (1961), however, relates that Hyde's unpublished dissertation (1959) reports evidence of weight conservation appearing in his Ss prior to volume conservation also. The discrepancy between these data and Piaget's might be due to differences in methodology since Piaget uses balance scales in his investigation of weight conservation and asks questions about what would happen if the transformed object were now counter-balanced against the standard object. This sort of conceptualization may involve more than the basic concept which was measured in the present study.

No sex differences were obtained for any of the phenomena which were

FIGURE 3

CUMULATIVE FREQUENCY OCCURENCES OF WEIGHT AND SIZE CONSERVATION WITH INCREASING AGE

(Control and Experimental Groups Combined, N=70)



examined. It would follow, therefore, that the concept of conservation of size is not influenced by the sex of the S.

To repeat, the hypothesis was that an adequate concept of "bigger" is a necessary, but insufficient, condition for evidencing size conservation. Data totally consistent with this hypothesis would require that all who evidenced size conservation also evidenced an adequate concept of "bigger." Such were the data obtained from this experiment except those obtained from a seven-year-old girl in the control group. In response to the question of, "Is one bigger than the other?", she replied, "No." When asked "Why?", she answered: "They were the same at first, but you made one taller and thinner." The choice of the word "taller" instead of "bigger" reflects a degree of sophistication inconsistent with her performance on the "concept-of-bigger" test. In that test she chose the "taller" and "smaller" object as being the "bigger" of the two. Her data are, nevertheless, inconsistent with the hypothesis. A corollary of the hypothesis examined is that there should be those who have an adequate concept of "bigger" but do not evidence size conservation. Nineteen of the Ss tested in this study fall in this category. Furthermore, because eight out of nine Ss who evidenced size conservation did also evidence an adequate concept of "bigger" the data are interpreted as providing strong support for the hypothesis.

SUMMARY AND CONCLUSION

The hypothesis examined by the present experiment was "that a multi-dimensional concept of 'bigger' is a necessary, but not sufficient, condition for a child to evidence size conservation." To assure that a sufficient number of children had an adequate concept of "bigger", in order to permit a test of this hypothesis, half of the Ss to be tested received training explicitly designed to this end. The other half received training in an object recognition problem, a task irrelevant to an adequate concept of "bigger." All Ss were then tested for size conservation and weight conservation. In addition, to provide some knowledge of the concept of "bigger" for the control Ss, these Ss were assessed in this regard as well.

Because there is strong evidence in the literature to suggest that size conservation is related to age, the Ss were divided into two groups on that basis: five and one-half to six and one-half years and six and one-half to seven and one-half years, with 20 Ss in each group. The Fisher Exact probability test analysis revealed a statistically significant difference between the experimental and control groups in regard to and adequate concept of "bigger" for both age groups, with the experimental groups evidencing the concept. In the older age group, the experimental Ss evidenced size conservation significantly more frequently than did the control group. The failure to find a significant difference between the experimental and control groups in regard to size conservation for the younger group is not inconsistent with the hypothesis inasmuch as an adequate concept of "bigger" is maintained as only a necessary, not an adequate, condition for evidencing size conservation. Futhermore, this finding is consistent with the notion that size conservation is related to age.

Unlike Piaget's findings, the data obtained in this experiment indicate that weight conservation appears at an earlier age than size conservation. It is pointed out, however, that this study is not the only one incongruent with Piaget in this matter.

In the final analysis, the results of this experiment suggest that data previously obtained with respect to the development of size conservation are confounded with the propaedeutic development of an adequate concept of "bigger."

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APPENDIX A

BLOCK SPECIFICATIONS - Experimental Group Training Session

BLOCK NUMBER	BLOCK DIMENSIONS (inches)			VOLUME (cubic inches)
	Height	Width	Depth	
1	3.00	3.50	3.50	36.75
2	2.00	3.50	3.50	24.50
3	1.00	3.50	3.50	12.25
4	3.00	2.50	2.50	18.75
5	2.00	2.50	2.50	12.50
6	1.00	2.50	2.50	6.25
7	3.00	1.50	1.50	6.75
8	2.00	1.50	1.50	4.50
9	1.00	1.50	1.50	2.25
10	3.00	.50	.50	.75
11	2.90	2.90	2.90	24.50
12	1.65	1.65	1.65	4.50
13	3.00	1.50	1.50	6.75
14	3.30	1.17	1.17	4.50
15	2.66	2.66	2.66	18.75
16	4.00	2.74	2.74	24.50
17	1.89	1.89	1.89	6.75
18	2.16	.89	.89	1.73
19	1.20	1.20	1.20	1.73

APPENDIX B

BLOCK TRAINING DATA SHEET

NAME_________________________(#___)AGE______DATE OF BIRTH________________

LOCATION___________________DATE_______TIME BEGUN______TIME FINISHED___

TRIALS NEEDED TO MEET CRITERION: PHASE I___, PHASE II___, PHASE III___, PHASE IV___.

PHASE I

1-A	___	No. 1, 3" Ver (B&T)	______	No. 5, 2" Ver	___
1-B	___	No. 6, 1" Ver (B)	______	No. 9, 1" Hor (T)	___
1-C	___	No. 4, 3" Hor (B)	______	No. 7, 3" Ver (T)	___
1-D	___	No. 1, 3" Ver (B)	______	No. 3, 1" Hor (T)	___
1-E	___	No. 8, 2" Ver (EH)	______	No. 5, 2" Ver (B&EH)	___
1-F	___	No. 7, 3" Hor (B&EH)	______	No. 9, 1" Hor (EH)	___
1-G	___	No. 4, 3" Hor (B&EH)	______	No. 6, 1" Hor (EH)	___
1-H	___	No. 3, 1" Ver (B)	______	No. 8, 2" Ver (T)	___
1-G	___	No. 4, 3" Hor (B&EH)	______	No. 6, 1" Hor (EH)	___
1-E	___	No. 8, 2" Ver (EH)	______	No. 5, 2" Ver (B&EH)	___
1-C	___	No. 4, 3" Hor (B)	______	No. 7, 3" Ver (T)	___
1-A	___	No. 1, 3" Ver (B&T)	______	No. 5, 2" Ver	___
1-H	___	No. 3, 1" Ver (B)	______	No. 8, 2" Ver (T)	___
1-B	___	No. 6, 1" Ver (B)	______	No. 9, 1" Hor (T)	___
1-F	___	No. 7, 3" Hor (B&EH)	______	No. 9, 1" Hor (EH)	___
1-D	___	No. 1, 3" Ver (B)	______	No. 3, 1" Hor (T)	___

PHASE II

2-A	___	No. 3, 1" Hor (B&T)	______	No. 7, 1½" Hor ___
2-B	___	No. 7, 3" Ver (T)	______	No. 5, 2" Ver ___ (B)
2-C	___	No. 2, 2" Ver (B)	______	No. 3, 1" Hor ___ (T)
2-D	___	No. 7, 3" Hor	______	No. 5, 2" Hor ___ (B&T)
2-E	___	No. 3, 1" Ver (B)	______	No. 6, 1" Hor ___ (T)
2-F	___	No. 3, 1" Ver (B)	______	No. 7, 3" Ver ___ (T)
2-G	___	No. 2, 2" Hor (B&T)	______	No. 3, 1" Ver ___
2-H	___	No. 3, 1" Hor (B&T)	______	No. 6, 1" Ver ___
2-B	___	No. 7, 3" Ver (T)	______	No. 5, 2" Ver ___ (B)
2-G	___	No. 2, 2" Hor (B&T)	______	No. 3, 1" Ver ___
2-F	___	No. 3, 1" Ver (B)	______	No. 7, 3" Ver ___ (T)
2-H	___	No. 3, 1" Hor (B&T)	______	No. 6, 1" Ver ___
2-D	___	No. 7, 3" Hor	______	No. 5, 2" Hor ___ (B&T)
2-C	___	No. 2, 2" Ver (B)	______	No. 3, 1" Hor ___ (T)
2-A	___	No. 3, 1" Hor (B&T)	______	No. 7, 1½" Hor ___
2-E	___	No. 3, 1" Ver (B)	______	No. 6, 1" Hor ___ (T)

PHASE III

		B&T	
3-A	___	No. 2, 2" Hor______	No. 4, 3" Hor___
			B&T
3-B	___	No. 8, 2" Hor______	No. 6, 1" Hor___
			B&T
3-C	___	No. 3, 1" Ver______	No. 4, 3" Ver___
			B&T
3-D	___	No. 8, 2" Hor______	No. 7, 3" Ver___
		B	T
3-E	___	No. 2, 2" Ver______	No. 4, 3" Ver___
		T	B
3-F	___	No. 8, 2" Ver______	No. 6, 1" Ver___
		T	B
3-G	___	No. 3, 1" Hor______	No. 4, 2½" Ver___
		T	B
3-H	___	No. 8, 2" Ver______	No. 7, 1½" Hor___
		T	B
3-G	___	No. 3, 1" Hor______	No. 4, 2½" Ver___
		T	B
3-H	___	No. 8, 2" Ver______	No. 7, 1½" Hor___
		B	T
3-E	___	No. 2, 2" Ver______	No. 4, 3" Ver___
		T	B
3-F	___	No. 8, 2" Ver______	No. 6, 1" Ver___
		B&T	
3-A	___	No. 2, 2" Hor______	No. 4, 3" Hor___
			B&T
3-D	___	No. 8, 2" Hor______	No. 7, 3" Ver___
			B&T
3-B	___	No. 8, 2" Hor______	No. 6, 1" Hor___
			B&T
3-C	___	No. 3, 1" Ver______	No. 4, 3" Ver___

PHASE IV

Item		Label	Stimulus		Label	Stimulus	
4-A	___	T&EV	No. 7, 3" Ver	______	EV	No. 13, 3" Hor	___
4-B	___	T&EV	No. 4, 3" Ver	______	EV	No. 15, CUBE	___
4-C	___	B&T	No. 2, 3.5x3.5	______		No. 4, 3" Ver	___
4-D	___	T&EV	No. 8, 2" Ver	______	EV	No. 12, CUBE	___
4-E	___	T	No. 8, 2" Ver	______	B	No. 7, 3" Hor	___
4-F	___	B	No. 2, 2" Ver	______	T	No. 4, 3" Ver	___
4-G	___	T&EV	No. 16, 4" Ver	______	EV	No. 11, CUBE	___
4-H	___	T	No. 8, 2" Ver	______	B	No. 6, 1" Ver	___
4-I	___	T&EV	No. 7, 3" Ver	______	EV	No. 17, CUBE	___
4-J	___	T&EV	No. 18, 2.16 V	______	EV	No. 19, CUBE	___
4-K	___		No. 3, 1" Ver	______	B&T	No. 4, 2½" Ver	___
4-L	___	T&EV	No. 14, 3.3"V	______	EV	No. 12, CUBE	___
4-M	___		No. 3, 1" Ver	______	B&T	No. 4, 3" Ver	___

Key to Symbols:

B= Bigger
T= Taller
EH= Equal Height
EV= Equal Volume

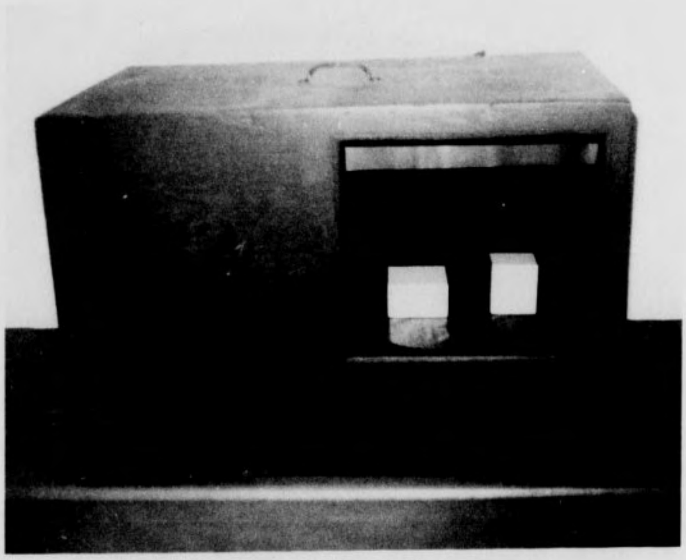
CONSERVATION TESTS:

VOLUME: Is one bigger than the other?______; Which one?______Why?

WEIGHT: Does one weigh more than the other?______; Which one?______
Why?

APPENDIX C

PHOTOGRAPHS OF APPARATUS



OBJECT PRESENTATION APPARATUS

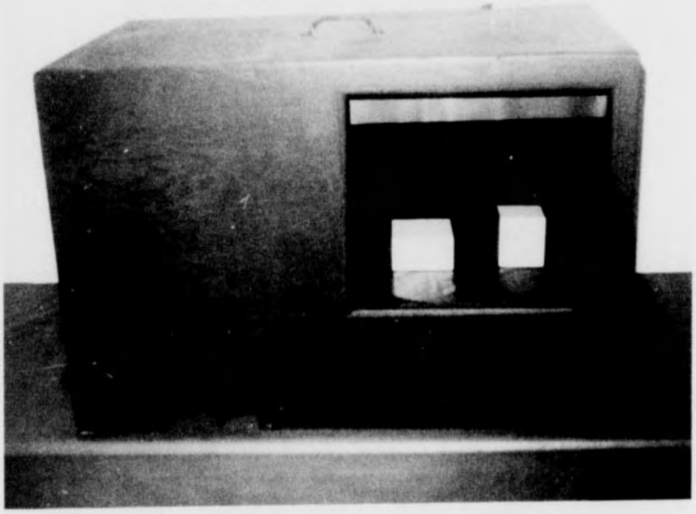
External Dimensions:

Height = 20 inches
Depth = 19 inches
Length = 30 inches

Aperture: 12 inches X 11 inches
Turntable: 13 inches in diameter

APPENDIX C

PHOTOGRAPHS OF APPARATUS



OBJECT PRESENTATION APPARATUS

External Dimensions:

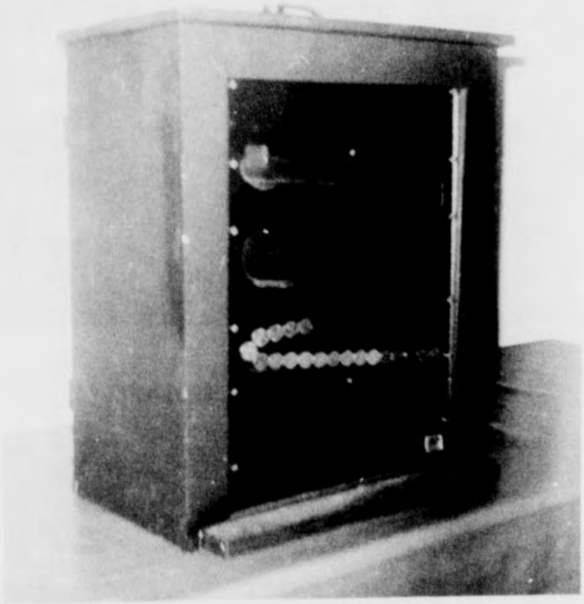
Height = 20 inches
Depth = 19 inches
Length = 30 inches

Aperture: 12 inches X 11 inches
Turntable: 13 inches in diameter

PENNY DISPENSER APPARATUS

External Dimensions:

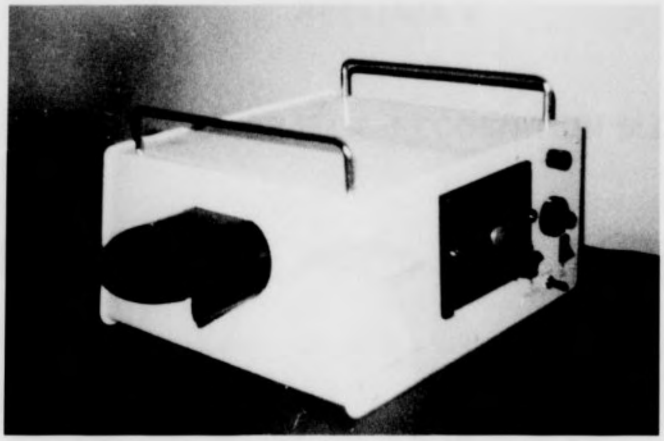
Height = 20 inches
Depth = 10 inches
Length = 18 inches



PENNY DISPENSER APPARATUS

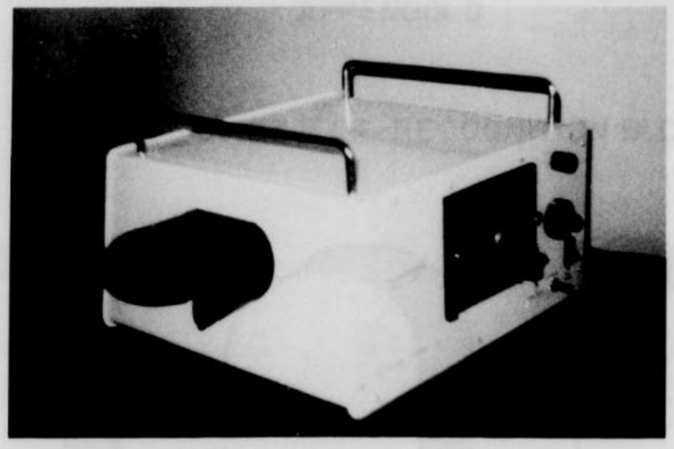
External Dimensions:

Height = 20 inches
Depth = 10 inches
Length = 18 inches



TACHISTOSCOPE

S Placing Block into Hole in
"Object Presentation Apparatus"

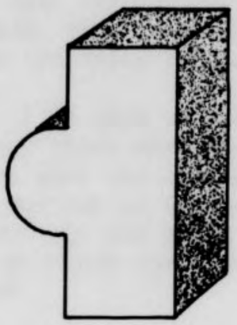


TACHISTOSCOPE

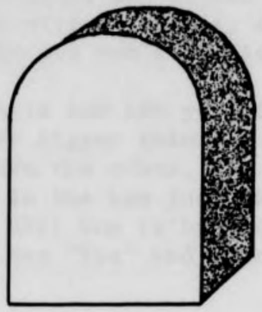
S Placing Block into Hole in
"Object Presentation Apparatus"

APPENDIX D

DRAWINGS OF OBJECT-RECOGNITION BLOCKS



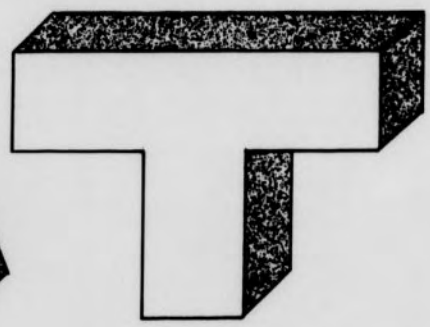
Standard Block



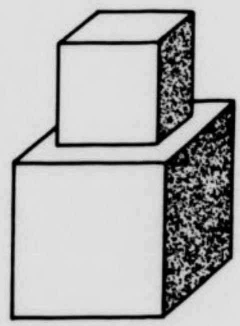
Block B

Block C

Block D



Block E



Block F

APPENDIX E

PAHSE IV INSTRUCTIONS TO EXPERIMENTAL Ss

After S had completed the first three phases, E read the following instructions:

Now, we are going to change the game a little bit. So far, one object has always been bigger than the other object. For this next part of the game, sometimes one object will be bigger than the other object (just like the last few times) but sometimes one object won't be bigger than the other object, they'll be the same size. That is, sometimes one will be bigger than the other and sometimes one won't be bigger than the other.

I'll show you two objects and ask you if one is bigger than the other. If you think that one is not bigger than the other one say "No". If you do think that one is bigger than the other, say "Yes" and pick up the bigger one and put it in the hole in the box just like before. I'll tell you again: If you don't think that one is bigger say "No" when I ask you. If you do think one is bigger say "Yes" and pick it up and put it in the hole. Okay?

APPENDIX F

EXPLANATIONS OF BLOCK-CHOICE PERFORMANCE TO EXPERIMENTAL Ss

1. WHEN S IS CORRECT AND THE OBJECT CHOSEN IS TALLER (AND BIGGER):

   "You were right, the block you chose is bigger. It is not just taller, it is bigger too, and that's because it took more wood to make it."

2. WHEN S IS CORRECT AND THE OBJECT CHOSEN IS SHORTER (AND BIGGER):

   "You were right. The block you chose is bigger. Even though it is shorter than the other block, it is so wide or fat that it took more wood to make it. So it is bigger than the other one."

3. WHEN S IS WRONG AND THE OBJECT CHOSEN IS TALLER BUT SMALLER:

   "The block you chose is not bigger. It's taller, but you see this other block is so much wider or fatter that it took more wood to make it. So, even though it is shorter, this one is bigger."

4. WHEN S IS WRONG AND THE OBJECT CHOSEN IS SHORTER AND SMALLER:

   "The block you chose is not bigger. It's not as tall [and it's not as wide either, (use this part only if applicable)] as this other object, so it didn't take as much wood to make it. So it is smaller. This other one is bigger than it is."

APPENDIX G

INSTRUCTIONS FOR OBJECT-RECOGNITION TASK *Ss*

I would like for you to look through this tunnel (E points to the viewing tunnel of the tachistoscope) and I am going to show you an object that I want you to try to remember. I want you to look at it very well and try to remember it because I want to see if you recognize it when you see it again. I'm going to show you a lot of objects and sometimes I will show you this one again too. You'll get just a very short view of the objects. What I want you to do is to tell me if the object I show you is the same one I asked you to remember. If you think that it is, say "Yes." If you don't think that the object you see is the one that I asked you to remember, say "No." Do you want to ask me any questions? Now, when I'm ready for you to see an object, I'll say "Ready?", and I want you to look at the white circle, because that is where the object will be when it appears. Okay?