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A STUDY OF DEVELOPMENT OF CONSERVATION OF QUANTITY.

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PIAGET'S THEORETICAL FORMULATION OF THE DEVELOPMENT OF CONSERVATION OF CONTINUOUS QUANTITY WAS EXAMINED. CONTROL SUBJECTS IN EACH OF TWO AGE GROUPS (5 AND 6 YEARS) WERE GIVEN A COMPLEX TASK SITUATION THAT IS TYPICAL OF PIAGET'S WORK. THESE SUBJECTS WERE ALSO GIVEN ANOTHER TASK, A MEASURE OF CONSERVATION OF QUANTITY THAT IS INDEPENDENT OF PIAGET'S THEORETICAL FORMULATION. EXPERIMENTAL SUBJECTS IN EACH OF THE 5- AND 6-YEAR GROUPS RECEIVED A LEARNING EXPERIENCE WHICH FOCUSED ON LOGICAL PERMANENCE PRIOR TO THEIR TAKING THE SAME INITIAL TASK TAKEN BY THE CONTROL GROUP. THE RESULTS WERE THAT CHILDREN 5 AND 6 YEARS OF AGE CONSERVE QUANTITY WHEN GIVEN THE PROPER EXPERIENCE AND THAT THEY SHOW STABILITY ACROSS TIME IN THEIR CONSERVING, THEREBY INDICATING THAT THE OPERATION IS MEANINGFUL TO THEM. THE FINDINGS, WHICH SUPPLY A CORRECTIVE TO PIAGET'S THEORY, HAVE WIDESPREAD EDUCATIONAL IMPLICATIONS SINCE THEY SHOW THAT CHILDREN IN THE KINDERGARTEN, WITH SKILLFUL GUIDANCE, WORK WITH QUANTITY AS A MEANINGFUL CONCEPT. (GD)

RF Project 2067

Report No. 2

FINAL

# REPORT

By

THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION

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On A STUDY OF DEVELOPMENT OF CONSERVATION OF QUANTITY THEORY, FINAL REPORT

For the period 1 June 1965 - 31 May 1966

Submitted by Herbert H. Muktarian and George G. Thompson
Department of Psychology

Date 1 June 1966

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It is with a deep sense of gratitude that I express my thanks to Dr. George G. Thompson who gave so generously of his time for the enrichment of this study. From him I have further gained the spirit of dedication to science and to the idea. I express my warmest appreciation and sincere thanks also to Dr. David L. Clark, for his constructive criticisms on the research proposal; to Drs. John E. Horrocks, Raymond C. Miles, and Robert J. Wherry, for their helpful suggestions; to Mr. Harold Haydan, Principal, for his kind cooperation during the collection of the data; to Mr. Arthur L. Dudycha, for his statistical consultation; and to my wife, Dorothy, for her patience and support, her valuable comments, and for constructing the neutral task.

H. H. Muktarian

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INTRODUCTION

In this study we shall examine Piaget's theoretical formulation of the development of conservation of (continuous) quantity. In The Child's Conception of Number, Piaget delineates in some detail what he considers to be the processes by which the child comes to conserve quantity. Utilizing a clinical-experimental method, he asserts that the child passes through three stages of development. Stage I is characterized by "gross quantity" or "uni-dimensional" quantity, which means to say that the child is able to consider only a given aspect of a quantity (such as height, cross section, number of glasses, etc.) separately, as though it were independent of the others. Thus in Figure 1, while the amounts in each comparison are the same,[1] some children will think, for instance in comparison #1 that there is less in (B1 plus B2) than in A2 because the level of the liquid is lower in the former. Other children will think that there is more in (B1 plus

[1]Figure 1 is a graphic illustration of Piaget's procedure. The child is first given two cylindrical containers of equal dimensions (A1 and A2) containing the same quantity of liquid. The liquid in A1 is then poured into two smaller containers of equal dimensions (B1 and B2) and the child is asked whether the quantity of liquid poured from A1 into (B1 plus B2) is equal to that in A2. We shall call this comparison #1. The child is asked to make subsequent comparisons in similar fashion.

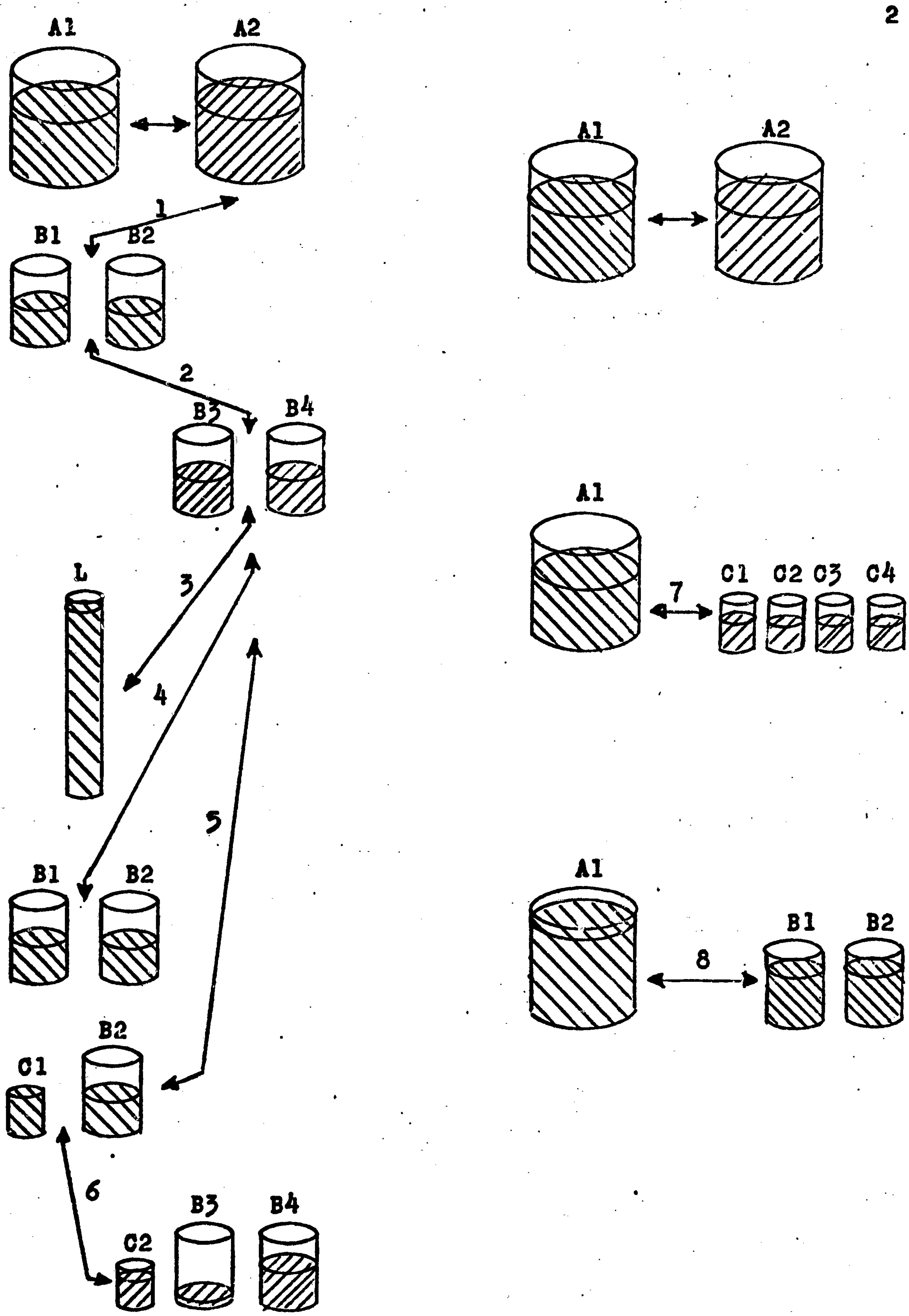
A1
A2
1
B1
B2
2
B3
B4
L
3
4
5
B1
B2
C1
B2
6
C2
B3
B4
A1
A2
A1
7
C1
C2
C3
C4
A1
8
B1
B2

Fig. 1.

B2) because there are two glasses in contrast to the one glass, A2. Still others will think that there is more in A2 because it has a larger cross section than either B1 or B2.

The child at stage II is, in Piaget's terms, having difficulty with the "logical multiplication of relations." That is, the child attempts to coordinate two or more aspects simultaneously, but without success. For example, the child may see that the amount in (B1 plus B2) is equal to that in A2. He sees that the cross section is smaller and the level of the liquid in B is lower than that in A2, but that there are two glasses, B1, B2 in contrast to the one glass, A2. However, in comparison #7 when he is asked to compare A1 with (C1 plus C2 plus C3 plus C4), he may think that there is more liquid in the latter, thus failing in logical multiplication.

Yet, even if the child were to succeed in logical multiplication this would not suffice for the conservation of quantity. That is, in comparison #5 the child may see that the cross section of the liquid in C1 is less than that in B3 and that the height in C1 is more than that in B3. But this is not sufficient to ascertain equality. What is necessary is the division of quantity into units that "are recognized as equal and yet distinct." At stage III the child "at a given moment . . . grasps that the differences compensate one another" and hence conserves quantity.[2] He sees for instance, that the loss in cross sec-

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[2]Italics mine.

tion in C1 is compensated by its gain in height and therefore that the amount in (C1 plus B2) is equal to that in (B3 plus B4).

It is to be noted that Piaget bases his theory on a procedure that employs a series of tasks which are complex, as is evident in Figure 1 and in the examples presented in Appendix I. Furthermore, Piaget is not consistent in his procedure from child to child and from age to age. The series in Figure 1 was given to a child four years of age (4-0). In Appendix I the procedures differ further.

When one considers the literature one is indeed surprised, if not alarmed, to see what in fact characterizes the research that is being done relevant to questions and problems that Piaget's findings impose. Lovell and Ogilvie (1960), for example, undertook a study of the conservation of substance in the school child in England. What they essentially did was to replicate some of the experiments presented by Piaget. In fact, an effort was made to stay as close to Piaget's procedure as was possible. The investigators did endeavor, however, to standardize the procedure. The measure that was taken was the proportion of children in a given grade that could be "placed" in a given stage. The results were that Piaget's theory of three stages was upheld for the most part, but that there was a good deal of variance in the findings for a given stage. In a similar fashion, Dodwell (1960) confirmed Piaget's contentions on the child's understanding of number and related concepts. Yet he too found great variability in his data. Such variability raises serious questions regarding the validity of Piaget's theoretical position.

Consider another study by Lovell et al. (1962a). The situation here is quite similar to that described above. This study also consisted essentially of a replication of some experiments presented by Piaget. The unique aspect of the study was to compare educationally subnormal children (ENS) with normal children using Piaget's stages as a framework. The experiments replicated were taken from Piaget et al (1960). The findings only "broadly confirmed" those of Piaget. Likewise, Woodward (1961) investigated the concept of number of the mentally subnormal and found that Piaget's intuitive and concrete stages could be seen in these children. With these studies it is evident that a theoretical structure is being used with disparate groups prior to adequate validation.

Other studies characterized by replication of Piaget's experiments are Lovell (1959) who investigated the child's conception of space and Lovell and Ogilvie (1961) who repeated Piaget's experiment on the concept of volume. So too with Lovell et al. (1962b) who investigated the growth of logical structure utilizing Piaget's concepts. Elkind (1961a) in this country set out to study the child's development of quantitative thinking. His was a "systematic" replication of Piaget's studies, which means to say that it was a bit more standardized in procedure. Elkind himself thought that his unique contribution in this study was the use of a statistical analysis on his data. He considered the absence of such to be a crucial factor with Piaget's studies. Elkind (1961b) proceeds similarly in his study on children's discovery of the conservation of mass, weight and volume.

It should be pointed out that some investigators have endeavored to examine Piaget's formulations though not directly related to that of conservation of quantity. Braine (1959) examined Piaget's formulation of both the development of concrete transitivity of length (length measurement) and the development of position order in children. He found concrete transitivity approximately two or three years before the age at which Piaget claims it first becomes available to children. Also, when the number of objects in a sequence was reduced, order discrimination was elicited at an age considerably earlier than the age at which Piaget claims it develops in children. However, Smedslund (1963) found data supporting Piaget against Braine on the development of concrete transitivity of length. Ojemann and Pritchett (1963) examined the role of guided experiences in the child's understanding of the concept of specific gravity. The results were that guided experiences facilitated the understanding of specific gravity. However, it should be pointed out that the posttest was quite similar to the preceding training period in many respects and that the posttest differed from the test Piaget had used. While the investigators did give Piaget's test after their own posttest, the posttest served (1) as a transition from training tasks to Piaget's tasks and (2) as a further learning experience for Ss.

A study more directly related to conservation of quantity is that of Frank (1964) in which, after giving a pretest of conservation of liquid volume to children, a screen prevented observation of subsequent transformations in the liquid's appearance. The results were that the children of all age groups (four, five, six and seven years) showed increases in correct equality judgments. Frank considers this to be an increase in conservation of liquid volume. But Piaget (1952) would say that Frank was not measuring conservation. What was measured was logical permanence. That is, the responses "It's the same water," or "You only poured it," refer to the fact that the child is simply identifying the water in its final state as being one and the same water that was used in its initial state. A child who conserves quantity, on the other hand, is one who is mentally equipped to see beyond the perceptual illusion and conclude that the quantity of liquid, though different in appearance, is the same.

In view of the literature cited above, it would seem quite appropriate to engage in a study that does critically analyze Piaget's theoretical formulation of conservation of quantity. Inasmuch as Piaget bases his thesis upon an investigation involving a complex task and a complex situation for the child (and he is quite consistent in doing this; see Piaget and Inhelder (1953) which deals with the pendulum problem, inclined plane, and others; also, see Inhelder (1953)), this would seem to be an appropriate starting point.

We ask, then, what essentially is Piaget measuring? Consider Figure 2. The amount in A1 is equal to that in A2. A2 is then poured into container B and questions are then put regarding the equivalence of the amount in A1 with that in B. This operation may be symbolically

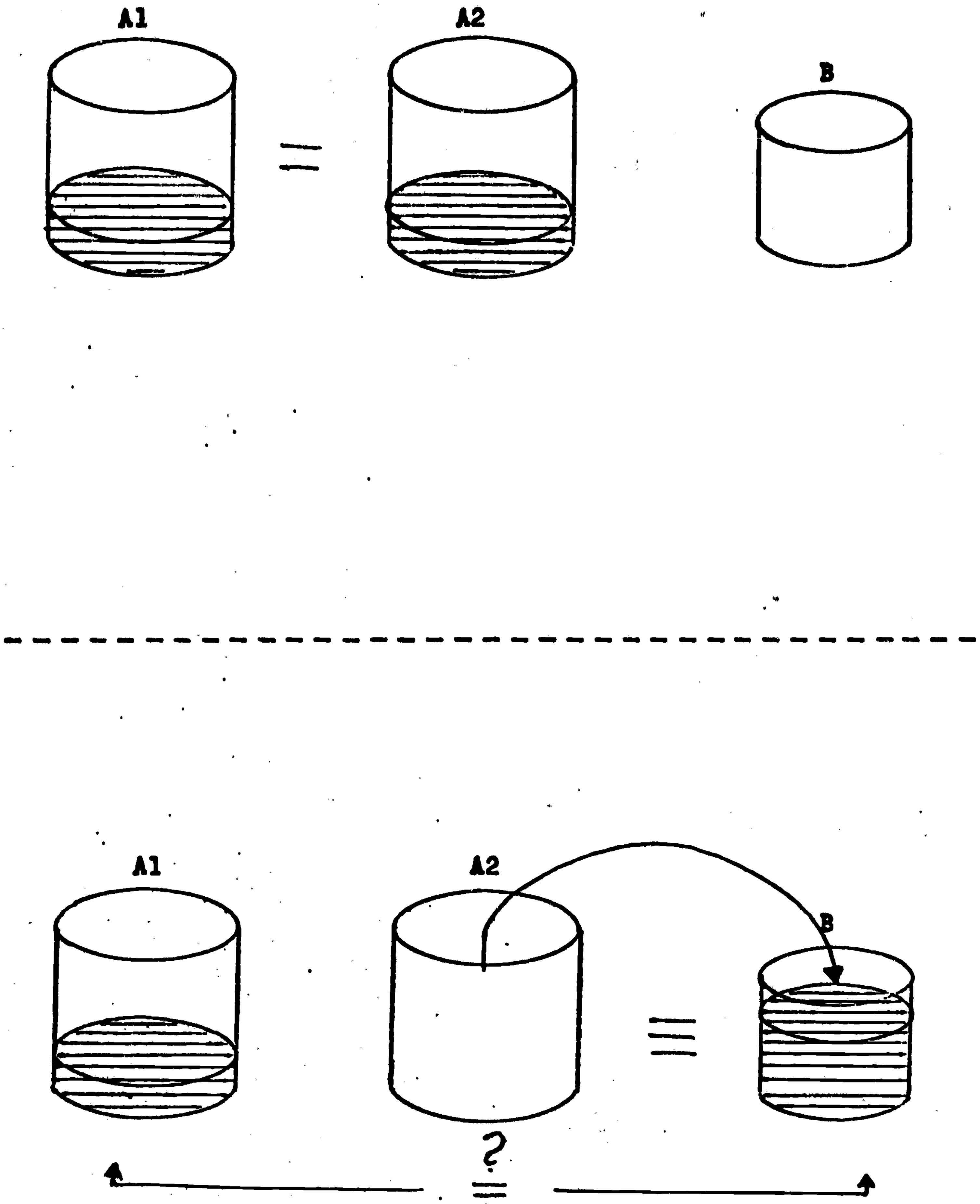


**Fig. 2.**

represented as follows:

$$\begin{array}{ll} A1 = A2 & \text{Given} \\ \underline{A2 = B} & \\ \therefore \; A1 = B & \end{array}$$

We observe that it is necessary that the child see that A2 = B if he is to make the correct inference. But this is a measure of logical permanence beyond the perceptual illusion. That is, the child does not have to know that the amount that was in A2 is equal to that which is in B. He simply has to see that what is in B is one and the same liquid that was in A2. It could, of course, be argued that the child may be thinking in terms of quantity. Even if this were the case, however, this would not free the operation from the influence of logical permanence. Piaget (1952) himself seems to have difficulty in keeping the issue clear. For him, those who conserve quantity "assume it as a physical and logical necessity." They see "the final and initial states as being identical." Indeed, in one instance it would appear that, by conservation Piaget really means logical permanence. The child who discovers conservation understands "that the liquid[3] remains the same since nothing is added to or subtracted from it."

Again, from the paradigm above, it is evident that while he may succeed in logical permanence, the child may not make the simple syllogistic deductive inference and hence still fail in Piaget's task. At best, then, Piaget has an interaction measure. At worse, he is not at all measuring conservation of quantity.

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[3] Italics mine.

## CHAPTER II

## PROBLEM AND METHOD

Piaget's theoretical formulation is as follows: The child's development of conservation of quantity is characterized by three distinct yet inseparable stages. In the first stage the child can think only in terms of gross quantity and therefore is not mentally equipped to understand or grasp conservation. In the second stage the child is capable of logical multiplication in some instances and in others he is not. Yet he is not mentally equipped to understand conservation. Only in the third stage can the child understand the equating of differences and hence discover conservation of quantity.

It is the view of this investigator that children whom Piaget would place in stages I and II can, with a special experience, conserve quantity. This position is contrary to Piaget who holds that these children are not mentally equipped to conserve quantity. It is also our view that Piaget is measuring logical permanence beyond the perceptual illusion, which is different from conservation of quantity.

### Method

Subjects. The subjects were 100 school children, with 40 children in each of two age groups, five years and six years, and 20 children in a third age group, eleven years, selected (at each age) at random from the classrooms of a representative elementary school in the Southwestern City Schools. The five year group ranged in age from 5-2 to 5-11 with a mean of 5-7; the six year group, from 6-1 to 6-11 with a mean of 6-6; the eleven year group, from 11-1 to 12-11 with a mean of 11-7.

Experimental design

Control. Twenty Ss (10 males and 10 females) in each of the five and six year groups were given a complex task situation (Task P) that is typical or representative of Piaget's work. These Ss were also given Task M, a measure of conservation of quantity that is independent of Piaget's theoretical formulation. Prior to administering both of these tasks, however, a neutral task requiring an amount of time comparable to that spent between E and the experimental group was given. One-half of the Ss in each age group (and in each sex) received Task P followed by Task M. The other half received these tasks in the reverse order. The data of the control Ss were collected prior to that of the experimental Ss.

Experimental. Twenty Ss in each of the five and six year groups received a learning experience which focused on logical permanence prior to their taking Task P. These Ss were also given a special experience designed to facilitate the discovery of conservation of quantity prior to their being given Task M. One-half of the Ss in each age group (and in each sex) received learning and Task P, followed in one week by learning and Task M, followed in yet one week by a retest on Task M. The other half received learning and Task M, followed in one week by a retest on Task M, learning and Task P.

After the data of the five and six year groups had been collected, the 20 Ss in the eleven year group were deprived of logical permanence prior to and during their taking Task P. In all instances, E worked with one child at a time.

Procedure

The neutral task. The neutral task entailed constructing either a circus or a farm scene on a flannel board as a joint effort between E and the control Ss. The child was free to choose the scene he would make and, since there were many pieces (e.g., clowns, balloons, horses, sheep, etc.) within a given scene, could make it as he desired. The primary function of the neutral task was to establish a constructive working relationship between E and S comparable to that provided the experimental group in the learning experience.

Piaget's task

The learning experience. S is shown the plastic containers represented in Figure 3a. The large container is placed on a white mat (bracket in diagram) separating it from the two small containers which also are on a white mat. Both mats overlay a black covering on the entire surface of the table. E then says to S:

> Here we have this container (box) and here we have these containers (boxes). Is this box different from these boxes (E gestures to the small containers) or is this one (large) the same as these? (E puts a smaller one next to the larger one and then into the (larger one). How is it different? (E then uses the terms that S uses).
>
> Let's put some koolade[1] in here (S helps E pour into the large box). It's not really koolade, but we'll make believe it is, O.K?

[1]Red food coloring, with a concentration of six drops per half-gallon.

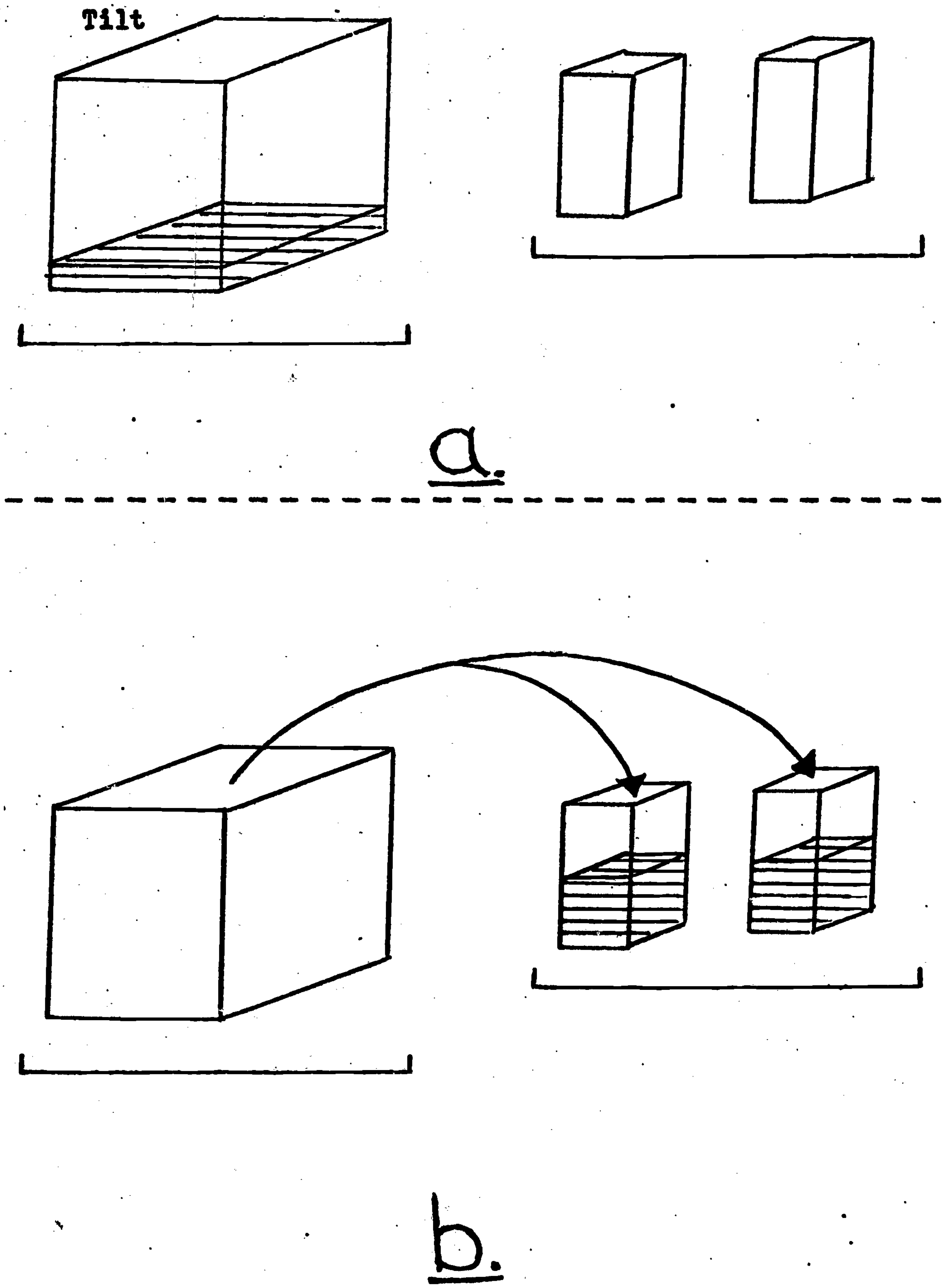
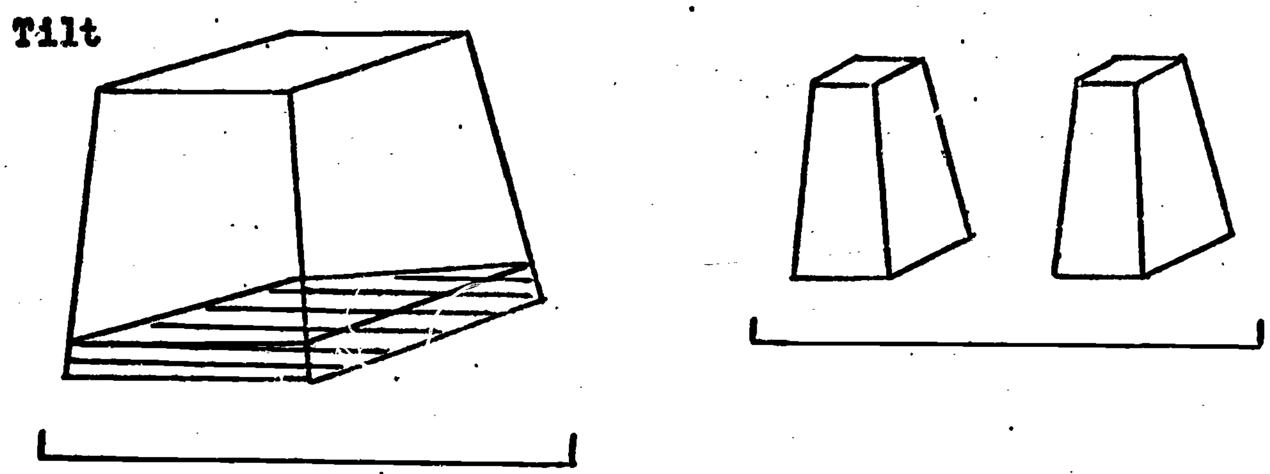
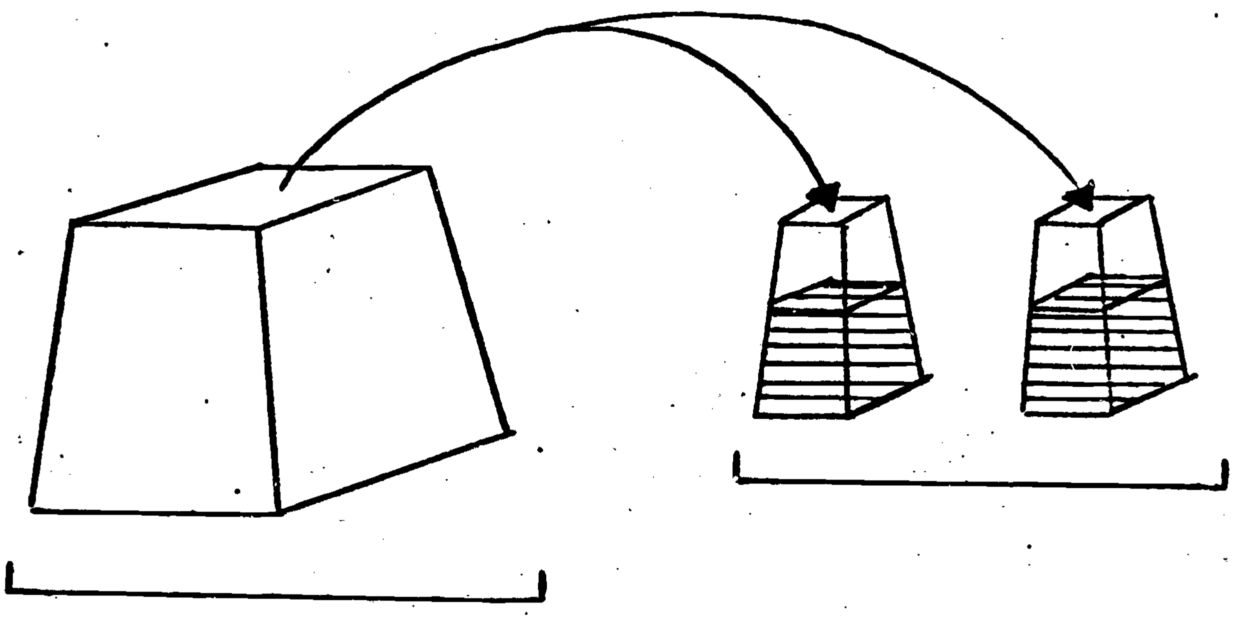



Fig. 3.




a.



b.

Fig. 4.

Let's see how the koolade looks. (E gestures, pointing out its shallowness and squareness). It's this way. And it's this way. You can stand up and look at it from the top.

Now let's do this. (E tilts big box so that it stands on its corner.) Did we drink any of the koolade? (Or, we didn't take any koolade out of the box, did we?) Did someone come in and give us more? So is there the same koolade in the box like this as there is like this (flat)? It looks different like this (tilted), doesn't it. How does it look different? Is it the same koolade? (E sets box down.)

Would the koolade look different if we put it in these (using S's term)?[2] Let's see how it would look. Here (in the big box) it's like this and it's this way (E gestures). O.K., let's put our koolade in these (using S's terms). (While E and S put koolade in smaller boxes) We didn't drink any of it, did we. And no one came in and gave us any more. (After E and S pour) Now we have all of our koolade in here (see Figure 3b). Is it the same koolade that was in here (larger one)? Yes, it is the same. But it looks different in these, doesn't it. Before it was this way (shallow). Is it this way (shallow) here? No, it isn't. And look at these from the top. Before it was this way (large square). And now there is this one and this one (E gesturing, pointing out smaller squares, using S's terms when possible). Is it the same koolade that we had in here (larger one)? Yes, it is the same.

(E and S then pour the koolade back into the larger box, making the same observations.)

This procedure is then repeated, using containers in the shape of a frustrum of a pyramid shown in Figure 4.

<u>Task P</u>. This task (see Figure 5) represents a <u>typical</u> series of manipulations by Piaget insofar as it includes the types of variation (change in cross section, level, number of glasses etc.) that he employs. It is simpler than Piaget's procedure (see Appendix I),

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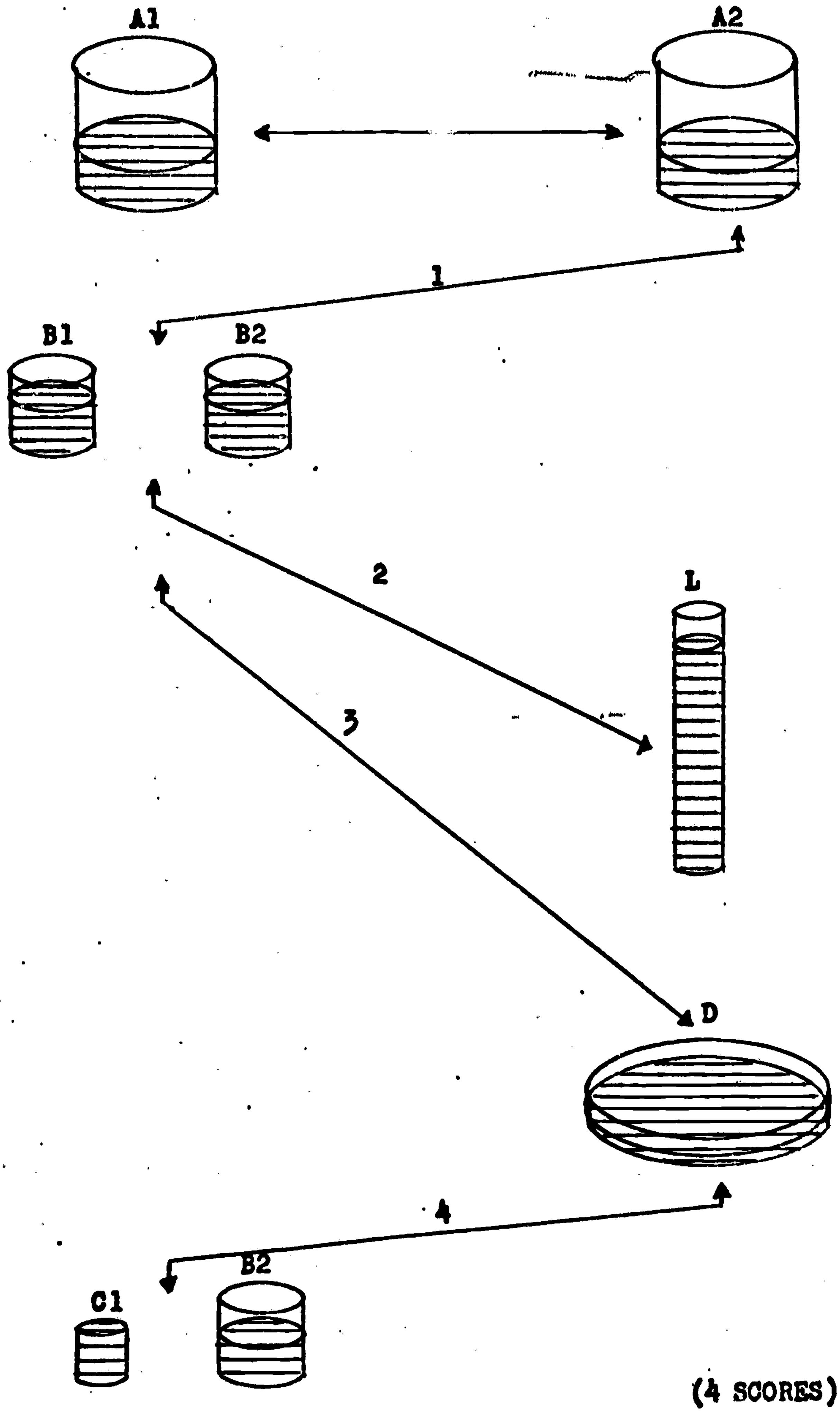
[2] E eliminates this question when going back from the two smaller containers to the larger one.




(4 SCORES)

Fig. 5.

however, in that the variation is systematic, i.e., the change in number of glasses is no more than from one to two (e.g., from A1 to B1 plus B2), the change in level of liquid is constant for a given change in cross section (e.g., the level in B1 equals that in B2), and the number of comparisons that S makes are fewer (namely, four).[3]

S is shown the plastic containers A1 and A2 (Figure 5) which are placed on a black mat covering the entire surface of the table. E then says to S:

> Here we have these containers. Let's see if they are the same. Are they the same this way? (E puts one cylinder on top of the other, demonstrating sameness of circumference.) Yes, they are the same this way, aren't they. Are they the same this way? (E demonstrates equivalence of height) Yes, they are the same this way. So this one is the same as this one, O.K?
>
> Do you have a nice friend? What's your friend's name? Alright, let's make believe that this is ____'s container (A1) and that this is your container (A2), O.K? So ____'s container and your container are the same. (E pours the same amount of koolade into each container.) Now ______ has some koolade to drink here (A1) and you have just as much koolade, the same amount of koolade to drink here (A2). So ______ and you have the same amount of koolade to drink.
>
> Now ______ puts his koolade in here (from A1 into B1 plus B2) like this. (S is then asked to make comparison #1): Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink? Why do you think it's the same? (Or, why do you think it's different? Should these questions fail to illicit a response, E may then ask) Does someone have

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[3]In this regard, it should be noted that Smock and Inhelder (1966) do not have a procedure that is typical of Piaget, since they have eliminated some types of variation that had serious bearing on the derivation of his theoretical formulation, i.e., change in number of glasses and change in the $r^2$ factor (see below).

more to drink? (Or, if S thinks the amounts are different, Who has more to drink?) Why?

E then pours the liquid from A2 into L and S is asked to make comparison #2 (the koolade in B1 plus B2 compared to that in L), with the same questions being asked. The procedure continues with E then pouring L into D and the child asked to make comparison #3, followed by E's pouring B1 into C1 and the child asked to make comparison #4. While S observes E's pouring procedure, for each comparison only those cylinders containing koolade are visible to S. Task P was given to all Ss in the five and six year groups without variation.

Logical permanence deprived. S is shown the containers A2 and B1 plus B2 (Figure 5) which are placed on a black mat. E then pours koolade, the amounts of which are the same as that in Task P, from white opaque pitchers into A2 and B1 plus B2. S is then asked to make comparison #1, with the same questions asked as above. When S would be less than certain in his replies, E would press him for a definitive answer. E then empties A2 into a white pitcher and replaces A2 with container L. E pours from a pitcher an amount of koolade into L equal to what was in A2 and S is then asked to make comparison #2. In similar fashion S is asked to make comparison #3 and #4. For each comparison only those cylinders containing koolade are visible to S.

Conservation of quantity

The special experience. S is shown two plastic containers, a smaller part and a larger part, represented in Figure 6a. Both parts are placed on a white mat (bracket in diagram) separating them from another white mat on which an intact container will subsequently be

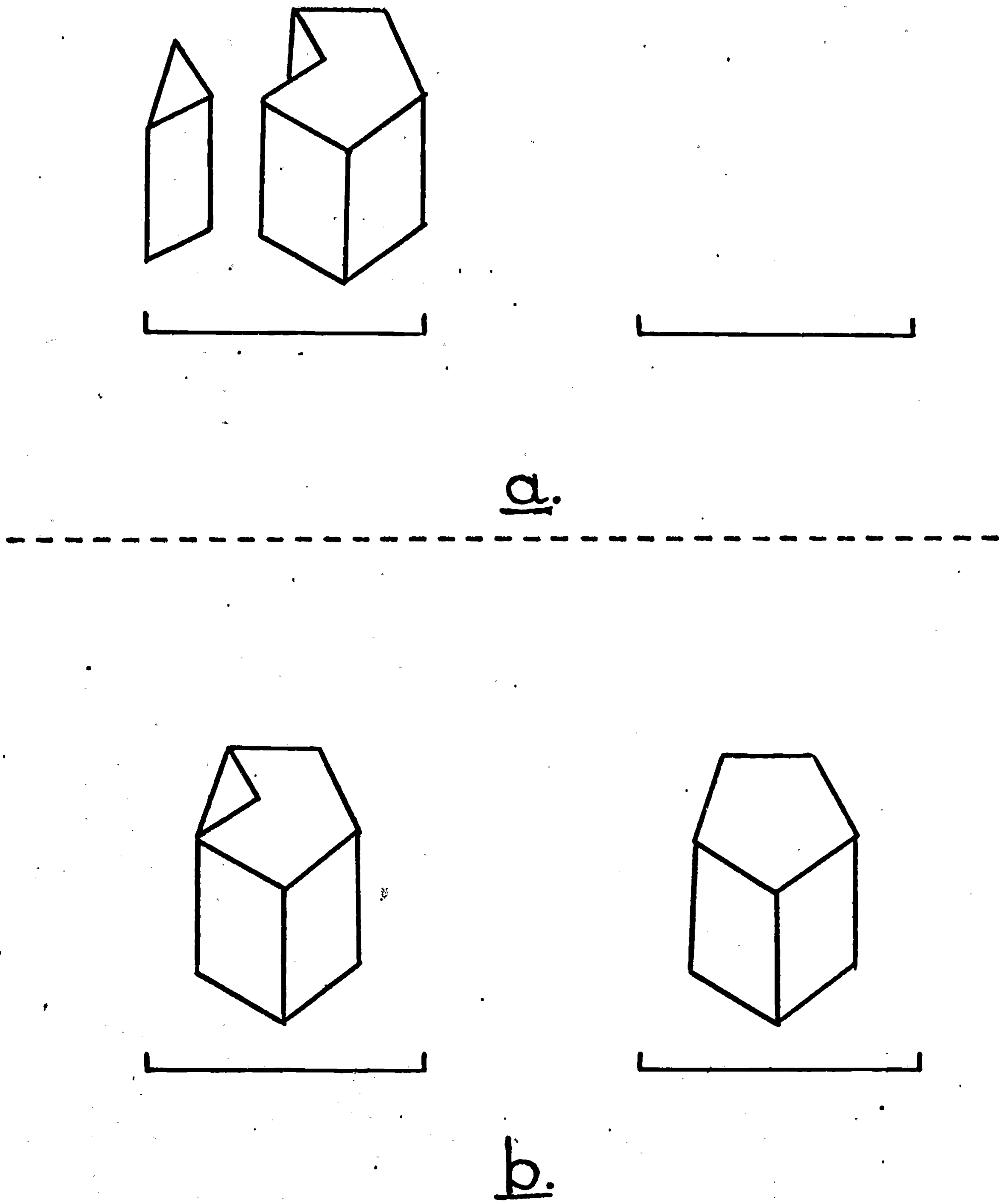



**Fig. 6.**

placed. Both mats overlay a black covering on the entire surface of the table. E then says to S:

Here we have these pieces. They go together so they fit. Let's put them together, O.K? (S does so, with E helping if necessary.) There. Now it's together. What does this (now joined container) look like to you? We can call it anything we want. (E subsequently refers to the joined container using S's term, e.g., "house," "star" etc.) It's a pretty star, isn't it? We can take the star apart (E does so) and we can put it back together again (E does so).

Do you have a nice friend? What's your friend's name? Alright, let's get a star for ______, O.K? (E does so.)

Here is a star for ______ (the intact container shown in Figure 6b) and it looks a lot like ours, doesn't it? Let's see if they are the same. (E puts the intact container on top of the joined container, demonstrating sameness of sides, perimeter.) Are they the same this way? Yes, they are the same this way, aren't they. (E then demonstrates equivalence of height.) Are they the same this way? Yes, they are the same this way. So ______'s star is just the same as our star when our star is together, O.K? (E makes especially clear this latter qualification.)

Now did you ever sell lemonade or orangeade? Did you sell some with your friends? Well, let's make believe that we're going to sell some koolade, O.K? We're going to sell some koolade in our star and ______ is going to sell some in his star. (Should S not be familiar with the game children play, E replaces the verb "sell" with simply the auxiliary verb "have" in what follows.)

So let's put some koolade in our star, O.K? This is not really koolade, but we'll just make believe it's koolade. (E and S fill joined container 1/4 full thereby bringing level of koolade to 1-1/2 inches from the base, E making sure the levels in each part are equal.) There. Now we have pretty red koolade in our star. (E has S stand up and observe how the koolade looks in the joined container. See Figure 7a.)

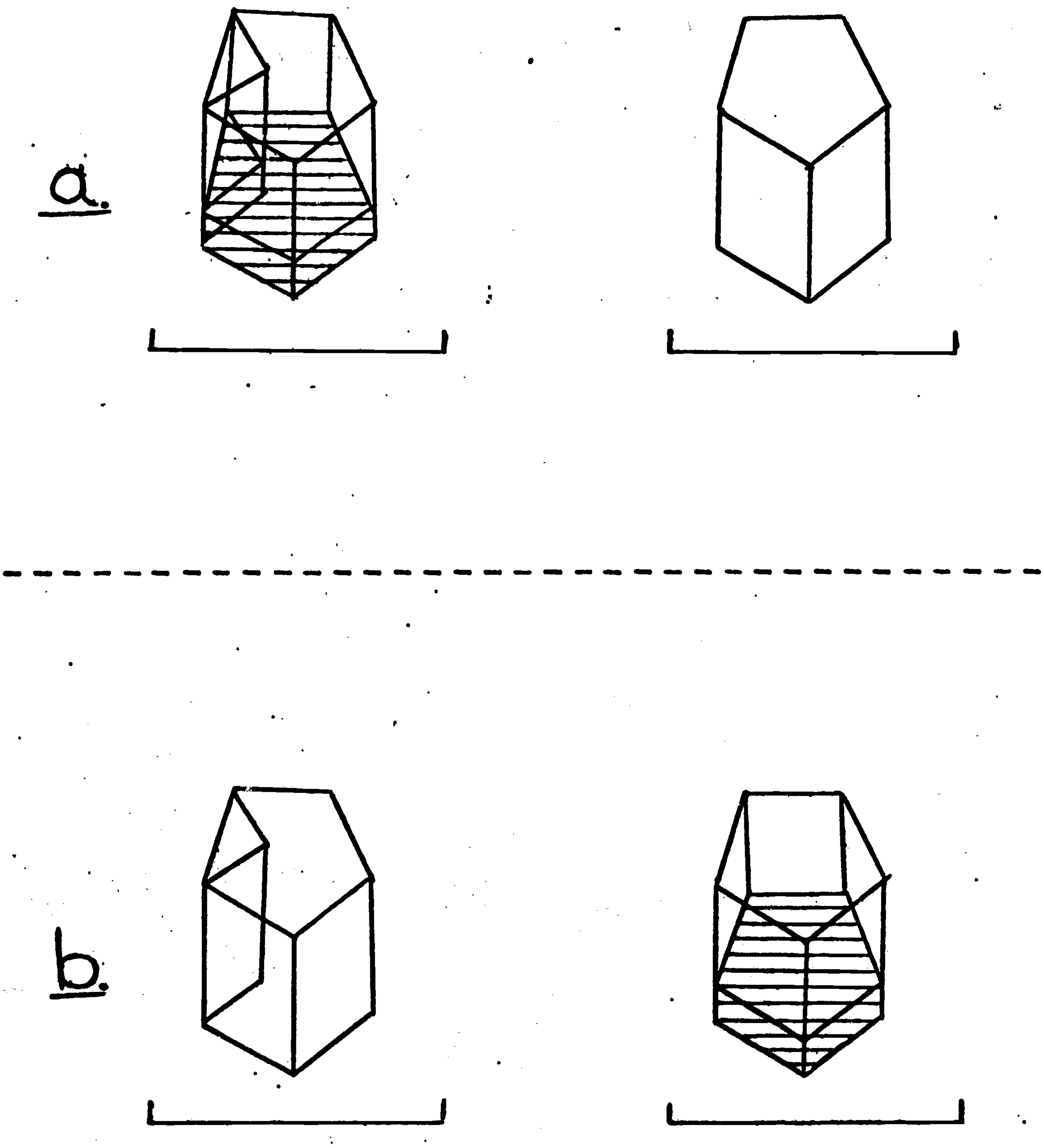



Fig. 7.

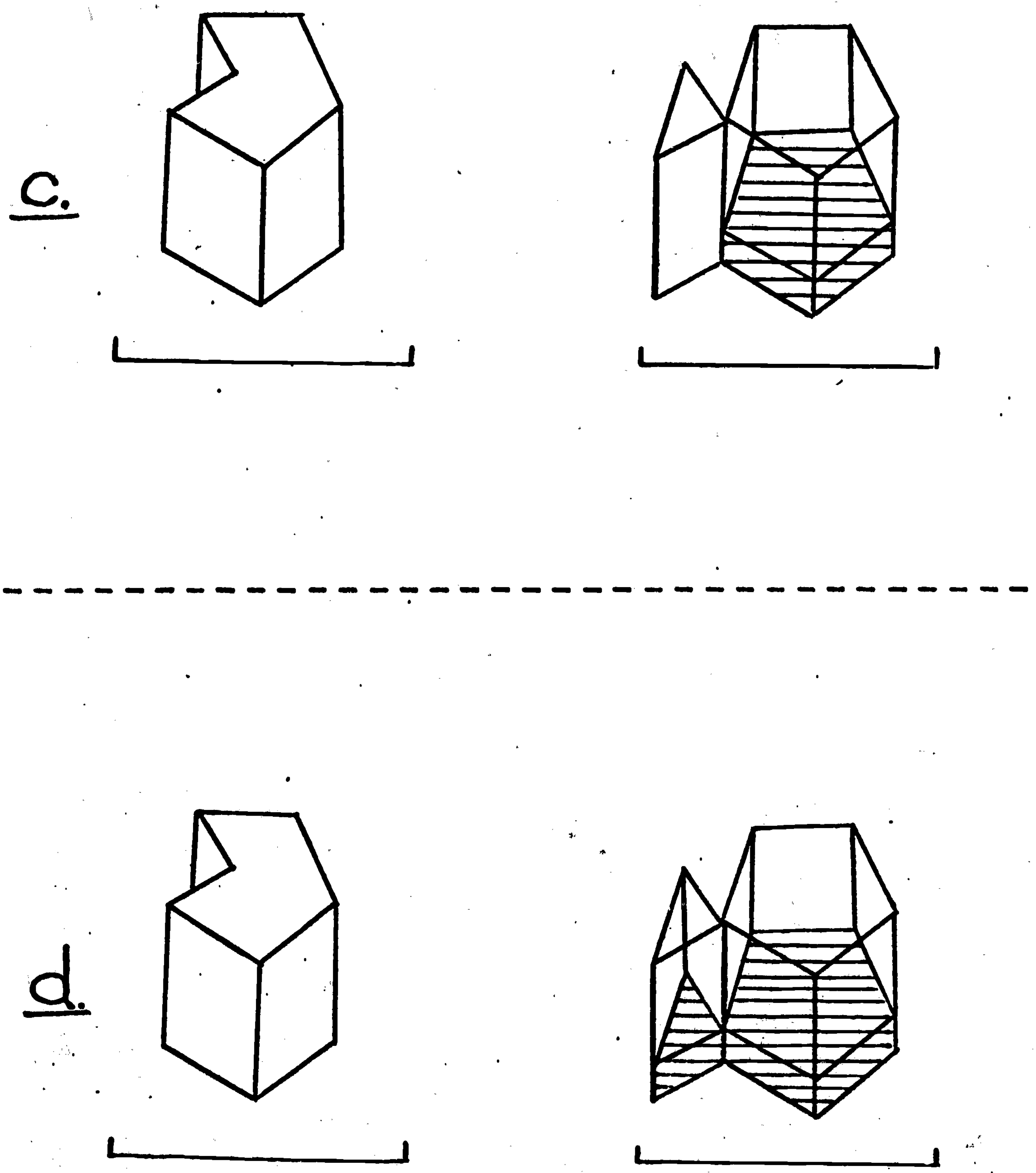
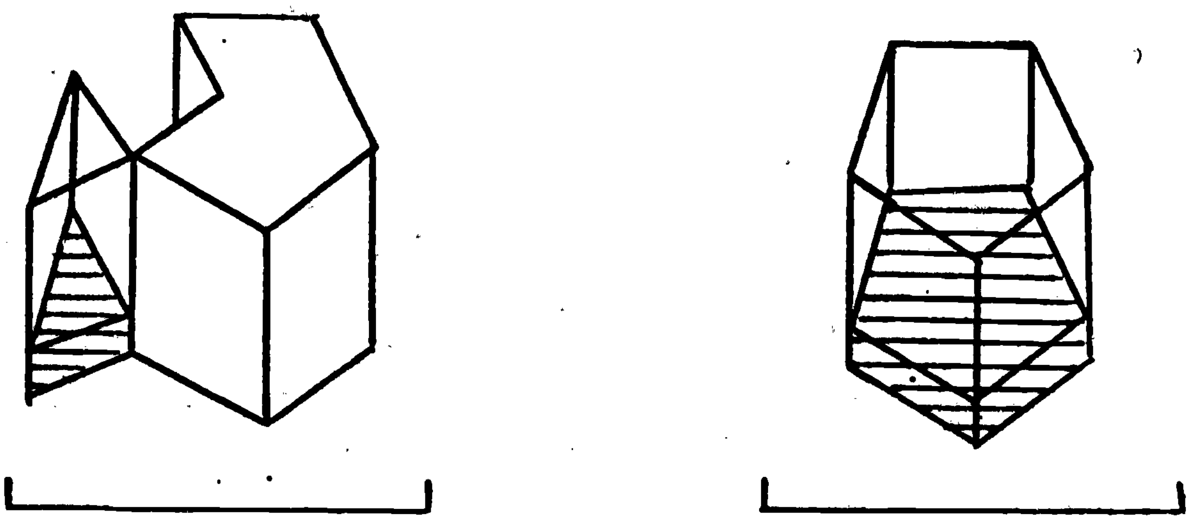



**Fig. 7** (Cont'd)

e.



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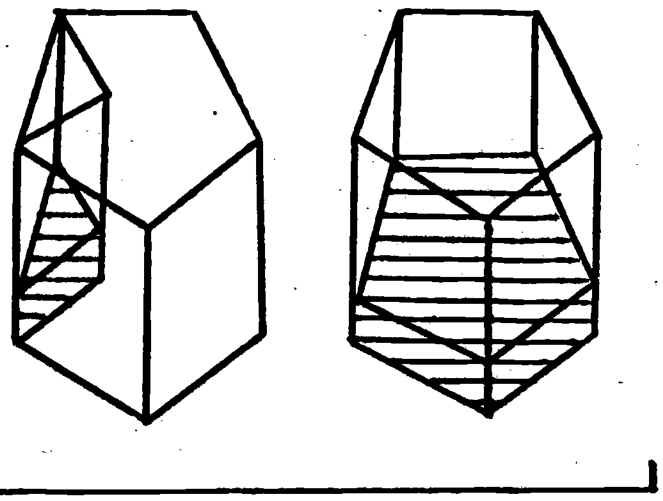
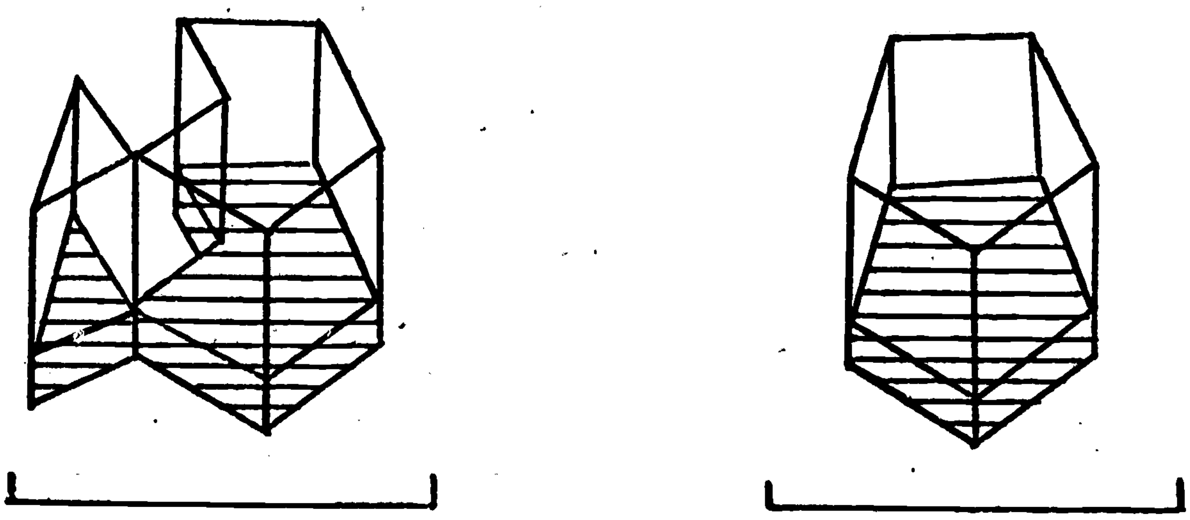


**Fig.** **7** (Cont'd)

g.



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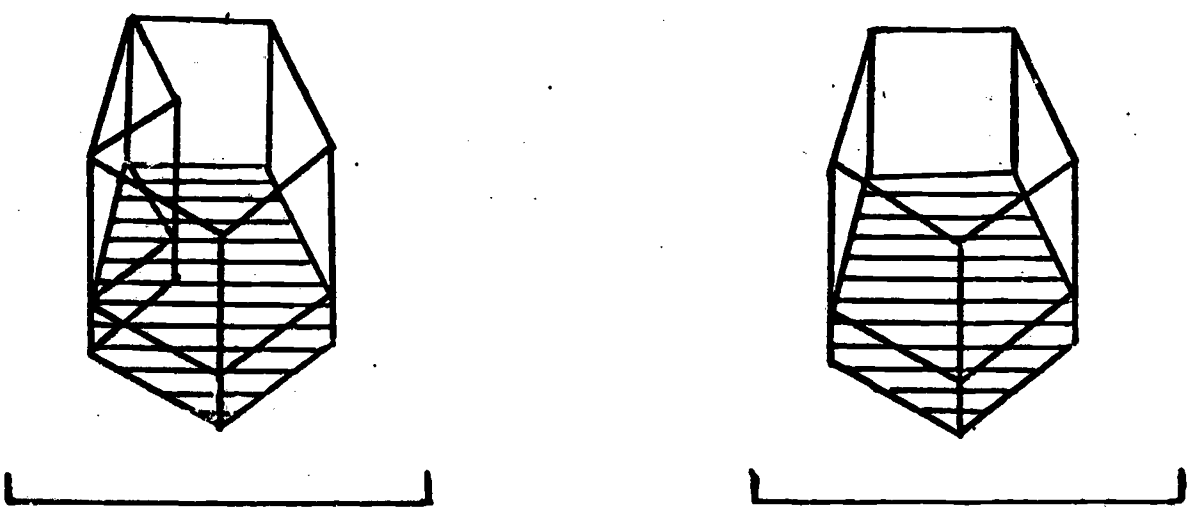


Fig. 7 (Cont'd)

Well, ______ wants to sell just as much koolade as we have in our star. ______ wants to sell the same amount of koolade that we have in our star. So let's give our koolade to ______ (E pours koolade from joined container into intact container.) Now ______ has just as much koolade in his star as we had in our star (the koolade looking the same in the intact as it did in the joined container, the level being 1-1/2 inches from the base. Figure 7b).[4]

Now I'm going to borrow this part for a moment, but I'll bring it back. (E takes smaller part and brings it to edge-contact with the intact container. Figure 7c.) We'll do this (E fills smaller part to the same level as the koolade in the intact container. Figure 7d. E then brings smaller part to edge-contact with larger part, Figure 7e). Do we now have just as much koolade to sell as ______?

(If S thinks that he has as much koolade as that in the intact container, E and S join the parts and place the joined container on the same white mat as the intact. See Figure 7f. E then works with S, showing him how they differ. E then puts parts back at edge-contact as shown in Figure 7e.)

(After S understands what has to be done) You put in here (larger part) so that we have just as much koolade as ______ (E handing S white opaque pitchers to do so. E also gives S a stainless steel scoop.) You can always take some out with this, if you need to. (As S pours) We want to have just as much koolade to sell as ______ has. After S is satisfied that the amounts are equal, as in Figure 7g) Why is it the same amount? (S may then join the parts as shown in Figure 7h.)

There's one way we can find out. (E and S put parts together and place joined container on the same white mat as the intact container.) You're right! Now we have just as much koolade to sell as ______ has (E gesturing, pointing out how the quantities are equivalent).

(If S is wrong.) Is that right? Do we have just as much koolade as ______? (E shows S how the two quantities differ.) Make it so that we have just as much as ______ (E handing S a scoop or a pitcher. If S has

---

[4]The intact container was fitted with an adjusted base thickness to provide for equivalence of both liquid volume and height of liquid from outside base with that of joined container.

difficulty at this point, E helps him). Now we have the same amount of koolade as ______. (E then puts joined container back on S's mat with parts at edge-contact, as shown in Figure 7g.) Why is it the same amount? How can we tell for sure? (E and S put parts together again and place joined container next to intact container.) You're right. We have just as much koolade to sell as ______ (E pointing out equivalence).

(E then empties the joined container and places it on S's white mat.) Now I'm going to borrow this part for a moment, but I'll bring it back. (E takes larger part and brings it to edge-contact with the intact container.) We'll do this (E fills larger part to the same level as the koolade in the intact container. E then brings larger part to edge-contact with smaller part). Do we now have just as much koolade to sell as ______? (The procedure is then the same as that above.)

The entire procedure is then repeated, only this time using the containers represented in Figure 8. They are filled 1/3 full thereby bringing level of koolade to 2 inches from the base.

Task M. S is shown two plastic containers, a smaller part and a larger part, represented in Figure 9. Both parts are placed on a white mat separating them from another white mat on which an intact container will be subsequently placed. Both mats overlay a black covering on the entire surface of the table. E then says to S:

Here we have these pieces. They go together so they fit. I'll put them together (E does so). There. Now it's together.

(E then presents the intact container, shown in Figure 9.) Here is another container. It looks a lot like that (joined) one, doesn't it? Let's see if they are the same. (E puts the intact container on top of the joined container, demonstrating sameness of sides, perimeter.) Are they the same this way? Yes, they are the same this way, aren't they. (E then demonstrates equivalence of height.) Are they the same this way? Yes, they are the same this way. So this one (intact) is the same as that one (joined) when it's together, O.K?

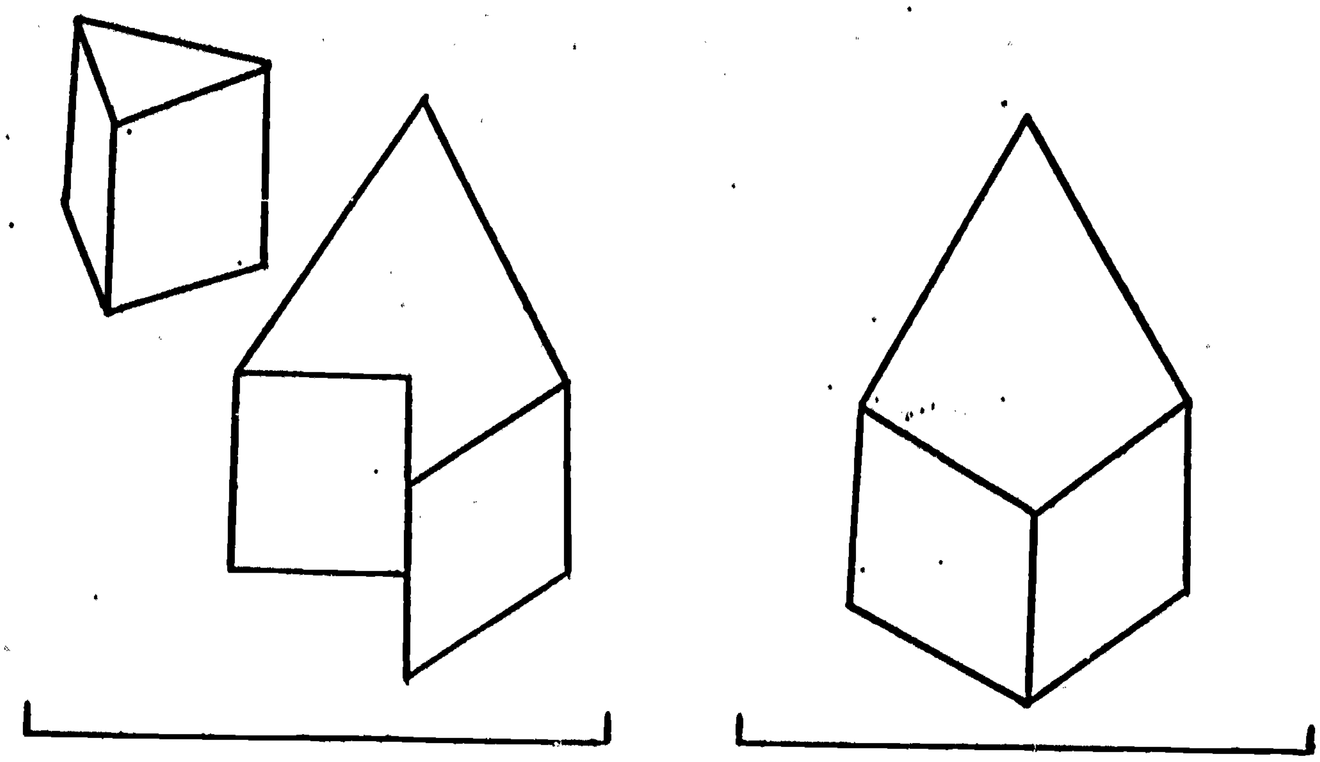


Fig. 8.

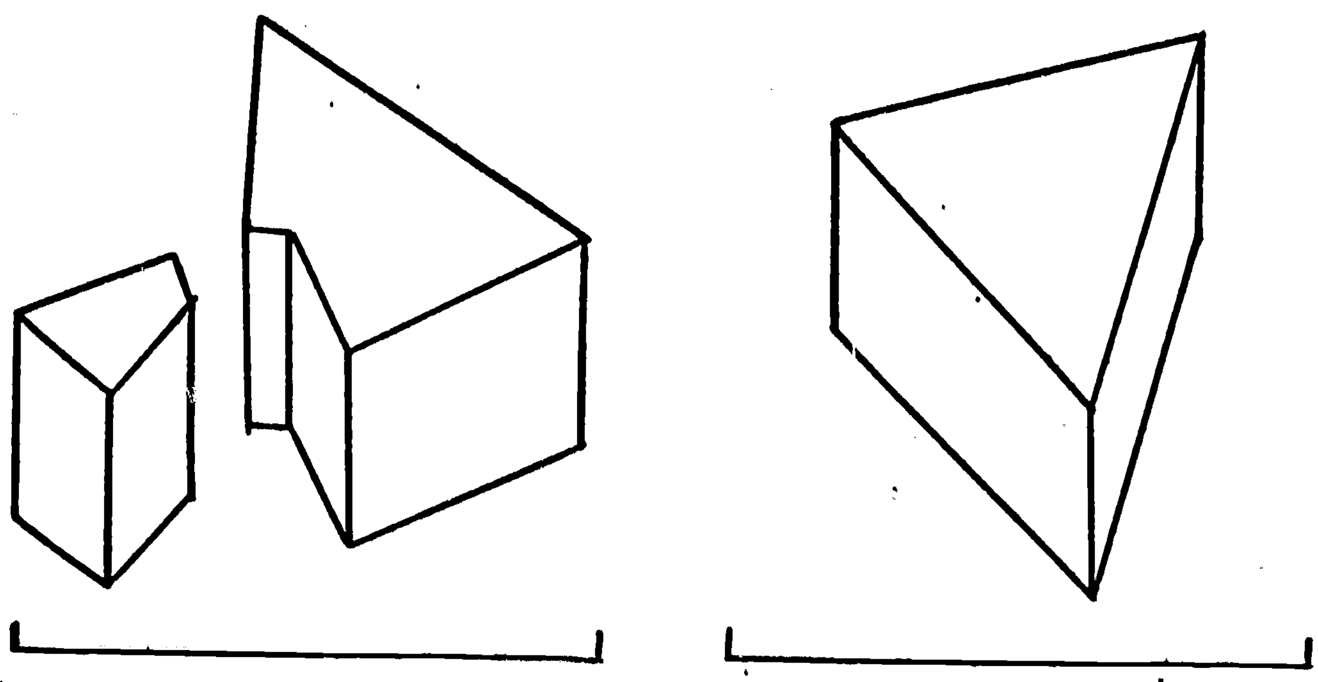


Fig. 9.

Do you have a nice friend? What's your friend's name? Alright, let's make believe that this is _____'s container and that this (joined) is your container, O.K? So _____'s container and your container are the same.

Now let's put some koolade in _____'s container (E and S fill intact container 1/8 full thereby bringing the level of koolade to 3/4 inch from the base). This is not really koolade. We'll just make believe it's koolade O.K? So _______ has this koolade here. This is your container, isn't it. Now I'll do this (E takes smaller part and brings it to edge-contact with the intact container, filling it to the same level as that in the intact. E then brings smaller part to edge-contact with larger part. See Figure 10a). Do you now have just as much koolade (here, on S's mat) as _______ has? (If S thinks the quantities are the same, E will say: Well then, let's do this. E will then proceed with rest of experiment.) Well, you make it so you have just as much koolade as _______ has. (E handing S a pitcher and a scoop) You can put some in with this (pitcher) or take some out with this (scoop). (After S has made adjustment) Why do you think it is the same?

(E then empties the joined container and places it on S's white mat, putting parts at edge-contact with each other. E and S then put more koolade into intact container, filling it 1/4 full thereby bringing level of koolade to 1-1/2 inches from the base.) Now I'll do this (The procedure is the same as above. See Figure 10b).

(E again empties the joined container and places it on S's white mat, as above. E then empties intact container to 1/8 full, bringing level of koolade to 3/4 inch from the base.) Now I'll do this (E takes larger part and brings it to edge-contact with the intact container, filling it to the same level as that in the intact. E then brings larger part to edge-contact with smaller part. See Figure 10c). The procedure is then the same as above.

(E empties the joined container and places it on S's white mat, as above. E and S then put more koolade into intact container, filling it 1/4 full, bringing level of koolade to 1-1/2 inches from the base.) Now I'll do this (The procedure is the same as the immediate above. See Figure 10d).

There are thus four measures of conservation of quantity. In each case, in order to conserve quantity it is necessary that S fill the proper

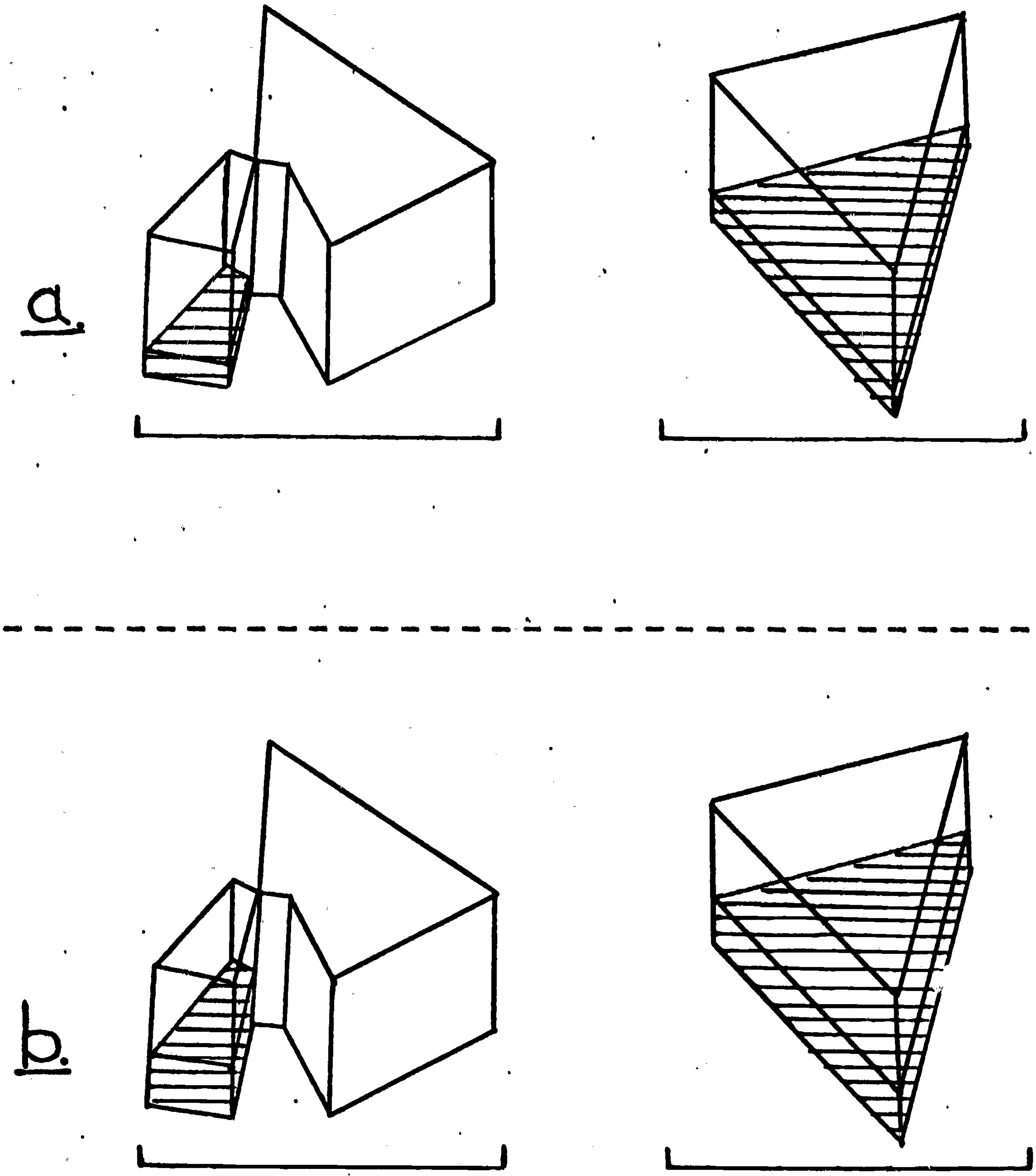
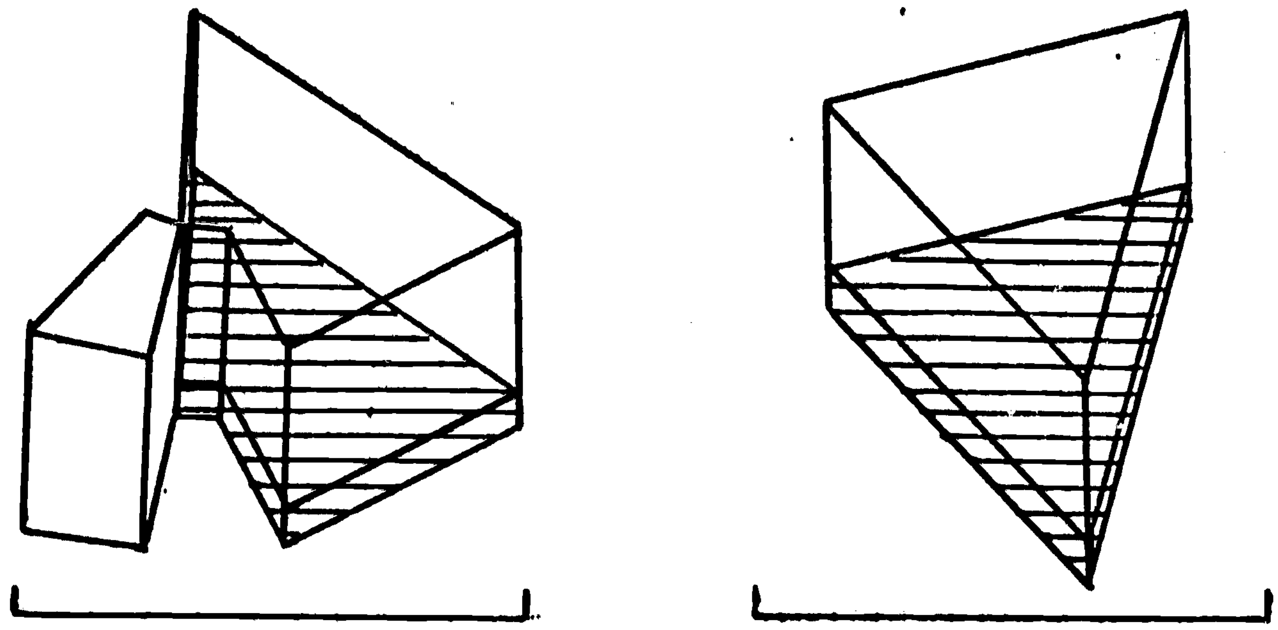



Fig. 10.

c.



d.

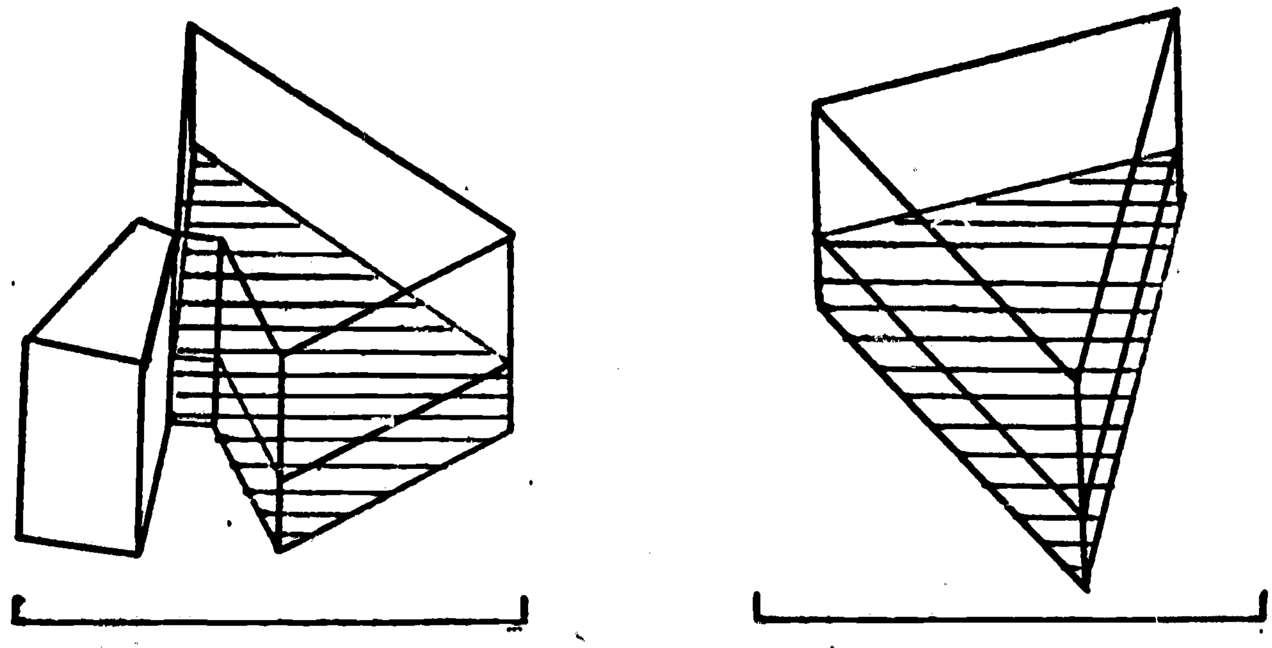


**Fig. 10** (Cont'd)

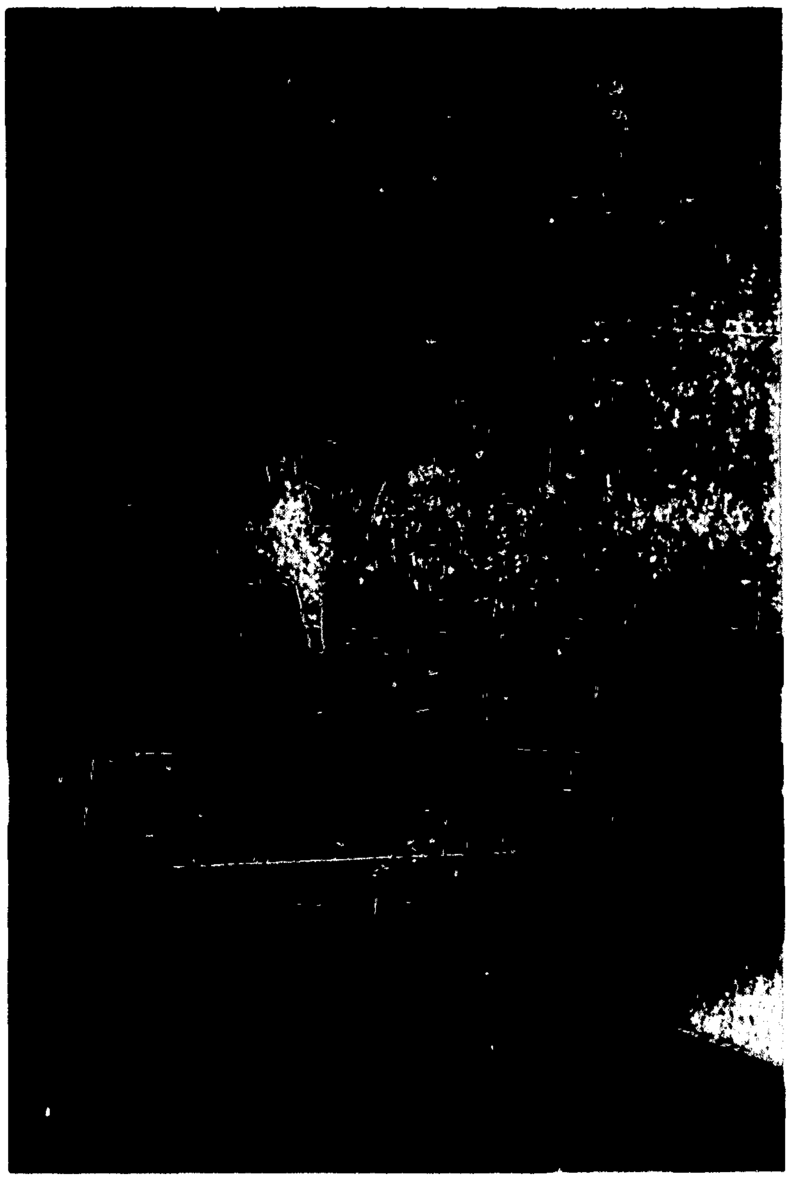


Fig. 11.

Fig. 11 (Cont'd)

Fig. 11 (Cont'd)

container to the proper level. While no verbal explanation is required in this operation, E inquires as to S's thinking. The photographs in Figure 11 show the relative size of the plastic containers to a typical child Cindy, 5-10. Figure 11a shows the child making the necessary adjustment which is seen in Figure 11b. When asked the reason for her action, she joined the parts as shown in Figure 11c and explained.

## CHAPTER III

## RESULTS AND DISCUSSION

### Analysis of variance I[1]

From Table 1 we see that the main effect of (experimental-control) condition is significant. This means that the learning experiences for Task M and for Task P had a significant effect. When we consider the AD interaction we find that the difference between experimental and control conditions varies by treatment levels (Task M and Task P). This is evident in Figure 12a where it is clear that the special experience

Table 1

Analysis of Variance I

| Source | df | MS | F | p |
|---|---|---|---|---|
| Between Subjects | 79 | | | |
| Sex (C) | 1 | 3.906 | 2.523 | |
| Condition (D) | 1 | 182.756 | 118.059 | < .001 |
| Age (E) | 1 | 18.906 | 12.213 | < .001 |
| CD | 1 | 12.656 | 8.176 | < .01 |
| CE | 1 | .006 | .004 | |
| DE | 1 | 31.506 | 20.353 | < .001 |
| CDE | 1 | .306 | .198 | |
| S(CDE) | 72 | 1.548 | | |
| Within Subjects | 80 | | | |
| Treatment (A) | 1 | 23.256 | 16.975 | < .001 |
| AC | 1 | 1.806 | 1.318 | |
| AD | 1 | 29.756 | 21.720 | < .001 |
| AE | 1 | 1.406 | 1.026 | |
| ACD | 1 | .306 | .223 | |
| ACE | 1 | 5.256 | 3.836 | |
| ADE | 1 | 2.256 | 1.647 | |
| ACDE | 1 | 1.806 | 1.318 | |
| AS(CDE) | 72 | 1.370 | | |

[1]Standard repeated measures ANOV designs were used throughout,

for Task M had a greater effect on Ss (in each age group) than that for Task P. Table 2 gives the analysis of these differences obtained by the Newman-Keuls (Winer, 1962) procedure.[2] Here it can be seen that the experimental Ss performed better on each task than the control Ss on either Task M or Task P. We see also that the experimental Ss did significantly better on Task M than on Task P. This latter finding is represented in Figure 12b.

We see by the DE interaction (Figure 12c) that the differences between experimental and control conditions varies by age (five and six year olds), with the greater difference being observed between the six year olds. This is seen to be the case for each task. The analysis presented in Table 3 shows that the experimental Ss in each age group performed better than either the five or six year control Ss. It is also evident that the experimental six year olds did significantly better than the experimental five year olds (see Figure 12d).

When we consider the five year group, we find that the experimental Ss did significantly better ($p<.01$) on Task M than control Ss. In the six year group, experimental Ss performed better ($p<.01$) than control Ss on each task.

The CD interaction (Figure 12e) indicates that the experimental and control differences vary by sex, with the greater difference

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treating all main factors as fixed and Ss as random.

[2]The Newman-Keuls method was used for all tests on differences between pairs of means.

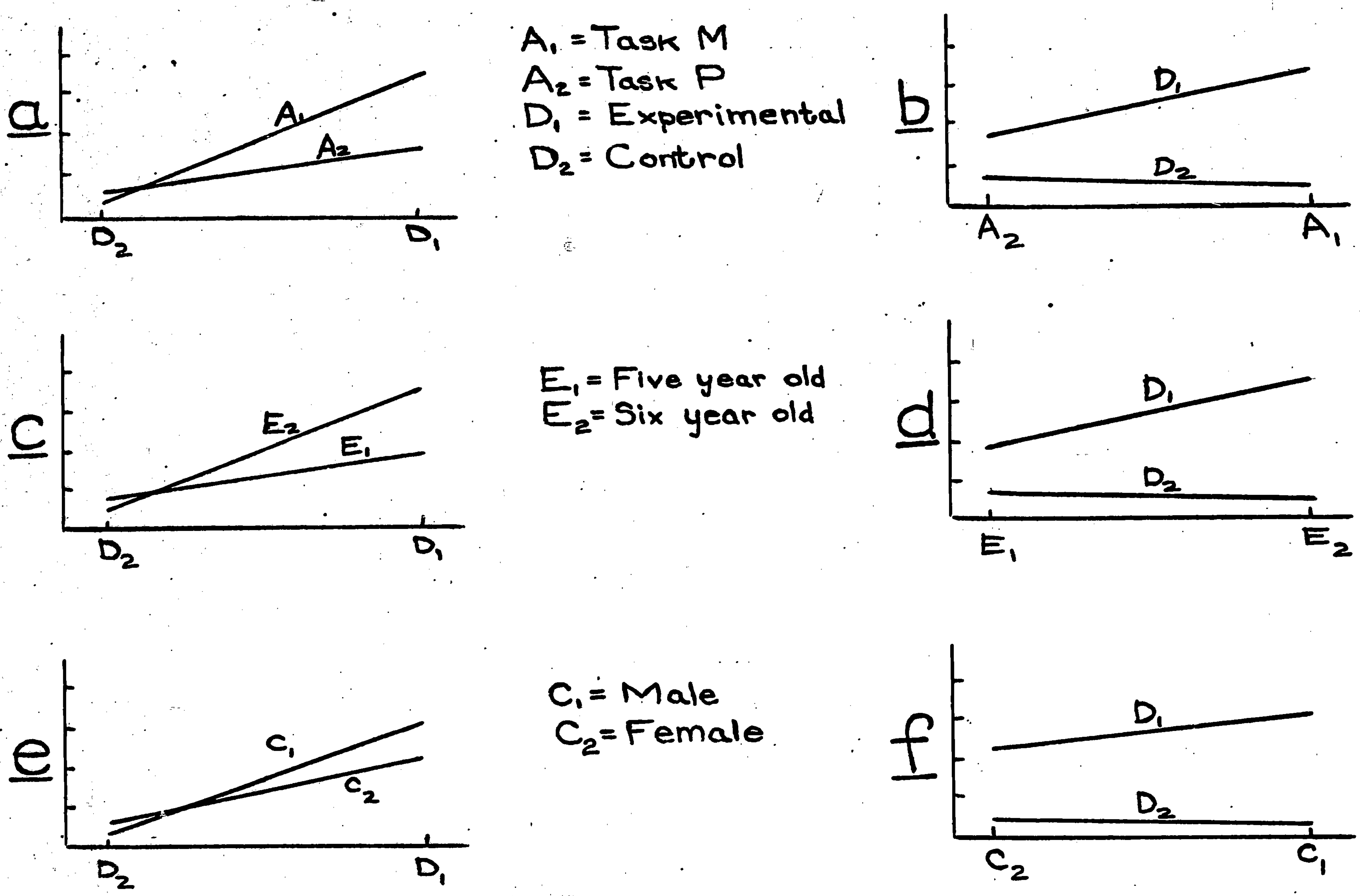
a
A1
A2
D2
D1
A1 = Task M
A2 = Task P
D1 = Experimental
D2 = Control
b
D1
D2
A2
A1
c
E2
E1
D2
D1
E1 = Five year old
E2 = Six year old
d
D1
D2
E1
E2
e
C1
C2
D2
D1
C1 = Male
C2 = Female
f
D1
D2
C2
C1

Fig. 12.

Table 2

Tests on Differences between All Pairs of Means for AD Interaction

| | A1D2 | A2D2 | A2D1 | A1D1 |
|---|---|---|---|---|
| | .3750 | .4750 | 1.7500 | 3.3750 |
| A1D2 | - | .1000 | 1.3750 | 3.0000 |
| A2D2 | | - | 1.2750 | 2.9000 |
| A2D1 | | | - | 1.6250 |
| A1D1 | | | | - |

| | r=2 | r=3 | r=4 |
|---|---|---|---|
| $q_{.99}(r, 72)$ | 3.75 | 4.27 | 4.58 |
| $\sqrt{\frac{MS_{error}}{n_i}}\ q_{.99}(r, 72)$ | .713 | .811 | .870 |

| | A1D2 | A2D2 | A2D1 | A1D1 |
|---|---|---|---|---|
| A1D2 | | | ** | ** |
| A2D2 | | | ** | ** |
| A2D1 | | | | ** |
| A1D1 | | | | |

$^{**}p < .01$

A1 equals Task M
A2 equals Task P
D1 equals Experimental
D2 equals Control

Table 3

Tests on Differences between All Pairs of Means for DE Interaction

| | D2E2 .3250 | D2E1 .5250 | D1E1 1.7750 | D1E2 3.3500 |
|---|---|---|---|---|
| D2E2 | - | .2000 | 1.4500 | 3.0250 |
| D2E1 | | - | 1.2500 | 2.8250 |
| D1E1 | | | - | 1.5750 |
| D1E2 | | | | - |

| | | r=2 | r=3 | r=4 |
|---|---|---|---|---|
| | $q_{.99}(r, 72)$ | 3.75 | 4.27 | 4.58 |
| $\sqrt{\frac{MS_{error}}{n_1}}$ | $q_{.99}(r, 72)$ | .750 | .854 | .916 |

| | D2E2 | D2E1 | D1E1 | D1E2 |
|---|---|---|---|---|
| D2E2 | | | ** | ** |
| D2E1 | | | ** | ** |
| D1E1 | | | | ** |
| D1E2 | | | | |

**$p < .01$

D1 equals Experimental
D2 equals Control
E1 equals Five year olds
E2 equals Six year olds

Table 4

Tests on Differences between All Pairs of Means
for CD Interaction

| | C1D2 | C2D2 | C2D1 | C1D1 |
|---|---|---|---|---|
| | .3000 | .5500 | 2.1250 | 3.0000 |
| C1D2 | - | .2500 | 1.8250 | 2.7000 |
| C2D2 | | - | 1.5750 | 2.4500 |
| C2D1 | | | - | .8750 |
| C1D1 | | | | - |

| | | r=2 | r=3 | r=4 |
|---|---|---|---|---|
| | $q_{.99}(r, 72)$ | 3.75 | 4.27 | 4.58 |
| $\sqrt{\frac{MS_{error}}{n_i}}$ | $q_{.99}(r, 72)$ | .750 | .854 | .916 |

| | C1D2 | C2D2 | C2D1 | C1D1 |
|---|---|---|---|---|
| C1D2 | | | ** | ** |
| C2D2 | | | ** | ** |
| C2D1 | | | | ** |
| C1D1 | | | | |

**$p < .01$

D1 equals Experimental
D2 equals Control
C1 equals Male
C2 equals Female

observed between the males. In Table 4 it can be seen that the experimental Ss in each sex performed better than either the male or female control Ss. We see too, that the experimental males did significantly better than the experimental females (see Figure 12f).

Analysis of variance II

Table 5

Analysis of Variance II

| Source | df | MS | F | p |
|---|---|---|---|---|
| Between Subjects | 39 | | | |
| Sex (C) | 1 | 21.675 | 6.486 | <.05 |
| Age (E) | 1 | 63.075 | 18.873 | <.001 |
| CE | 1 | 1.408 | .421 | |
| S(CE) | 36 | 3.342 | | |
| Within Subjects | 80 | | | |
| Treatment (A) | 2 | 32.708 | 32.161 | <.001 |
| AC | 2 | .175 | .172 | |
| AE | 2 | 2.275 | 2.237 | |
| ACE | 2 | 3.908 | 3.843 | <.05 |
| AS(CE) | 72 | 1.017 | | |

From Table 5 we see that the main effect of treatment is significant. In this analysis there are three treatment levels: Task P, Task M and Retest on Task M. It is evident in Table 6 that the performance of the experimental Ss in each age group on the retest did not differ significantly from their initial performance on Task M. From this retention measure it would appear that conserving quantity was meaningful to these five and six year olds.

Analysis of variance III

It is evident in Table 7 that the main effect of age is significant. In this analysis there are three age levels: five, six and

Table 6

Tests on Differences between All Pairs of Means for Treatment as a Main Effect

| | A3 1.7500 | A2 3.2500 | A1 3.3750 |
|---|---|---|---|
| A3 | - | 1.5000 | 1.6250 |
| A2 | | - | .1250 |
| A1 | | | - |

| | | r=2 | r=3 |
|---|---|---|---|
| | $q_{.99}(r, 72)$ | 3.75 | 4.27 |
| $\sqrt{\frac{MS_{error}}{n_i}}$ | $q_{.99}(r, 72)$ | .600 | .683 |

| | A3 | A2 | A1 |
|---|---|---|---|
| A3 | | ** | ** |
| A2 | | | NS |
| A1 | | | |

**p<.01

A1 equals Task M
A2 equals Retest on Task M
A3 equals Task P

eleven year olds. We see in Table 8 that the experimental six year olds did significantly better than the experimental eleven year olds

Table 7

Analysis of Variance III

| Source | df | MS | F | p |
|---|---|---|---|---|
| Between Subjects | 59 | | | |
| Sex (C) | 1 | 3.750 | 2.011 | |
| Age (E) | 2 | 20.267 | 10.867 | <.001 |
| CE | 2 | 5.000 | 2.681 | |
| S(CE) | 54 | 1.865 | | |

on Task P. These data would indicate the extent to which the learning experience in logical permanence facilitated the performance of the six year old Ss on Piaget's task.

<u>Protocols</u>

Some typical protocols are here presented to show the kind of thinking Ss verbalize during the operations themselves.[3]

Jacqueline, 5-5.
<u>Pentagon</u>. (S helps E in filling smaller part to the same level as intact. The situation then is as shown in Figure 7e. Do we now have just as much koolade to sell as _______?) Uh-uh (meaning "No." E then works with S).

(After S is satisfied that the amounts are equal, as in Figure 7g, Why is it the same amount?) We have our whole diamond full. (Show me. E helps S in her joining the parts.)

(Procedure repeated, using larger part. Referred to as Round 2. S again helps E in establishing equivalence of levels, as above.) You need some more. (How's that?) Fine.

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[3]The protocols selected are representative of those of the total sample.

Table 8

Tests on Differences between All Pairs of Means for Age as a Main Effect

| | E1 .7500 | E3 1.5500 | E2 2.7500 |
|---|---|---|---|
| E1 | - | .8000 | 2.0000 |
| E3 | | - | 1.2000 |
| E2 | | | - |

| | | r=2 | r=3 |
|---|---|---|---|
| | $q_{.99}(r, 54)$ | 3.78 | 4.31 |
| $\sqrt{\frac{MS_{error}}{n_i}}$ | $q_{.99}(r, 54)$ | 1.17 | 1.34 |

| | E1 | E3 | E2 |
|---|---|---|---|
| E1 | | | ** |
| E3 | | | ** |
| E2 | | | |

$^{**}p < .01$

E1 equals Five year olds
E2 equals Six year olds
E3 equals Eleven year olds

(Do we now have just as much koolade to sell as ______?) No (Clearly). (What are we going to have to do?) Get some in here (smaller part).

(Why is it the same amount?) In the whole diamond. (What is?) This and this one (parts). (I.e., the koolade is in the whole "diamond.")

Kite. (See Figure 8. S helps E with levels. How's that?) Whoa. That means "stop."

(Do we now have just as much koolade to sell as ______?) Uh-uh.

(Why is it the same amount?) 'Cause we have some in here and here (parts). In the whole diamond. (S may have joined parts here.)

Round 2. (S helps E with levels. How's that?) No, a little bit more. There.

(Do we now have just as much koolade to sell as ______?) Uh-uh (assertively). (S advances the information that she understands what has to be done, i.e., fill other part and put them together.)

(S overpours, elects to take some back out.) (Why is it the same amount?) Because . . . (Go ahead) 'Cause we poured some in the whole diamond. (S may have joined parts, here.)

Task M. (See Figure 10a. S helps E with levels.) Little bit more. There.

(Do you now have just as much koolade to sell as ______?) No (clearly).

(After S has made adjustment. Why do you think it is the same?) It's the same mountain. (How do you know?) 'Cause, you put that one (smaller part) over here (next to intact) . . . just as high and then I poured some (in larger part) just like in this (smaller part). (And why does, go ahead, what were you going to do? S then joins parts.)

Round 2. (See Figure 10b. S helps E with levels.)

(Do you now have just as much koolade to sell as ______?) No (clearly). (S overpours and corrects.)

(Why do you think it is the same?) 'Cause, I got a whole mountain. (How is it the same as his?)

Round 3. (See Figure 10c. S helps E with levels.)

(Do you now have just as much koolade to sell as ______?) No (clearly). He has more than I do (and S knows why).

(S overpours deliberately. She likes the stainless steel scoop and delights in using it.) It's higher. (S corrects.) (Why do you think it is the same?) Put it together (S does so).

Round 4. (See Figure 10d.)

(Do you now have just as much koolade to sell as ______?) No (S overpours). That's too much (S corrects, using the scoop).

(Why do you think it is the same?) 'Cause I put some more in. (Why does that make it just as much as ______?) 'Cause. I poured some in the whole mountain (S joins the parts).

Notice that S distinguished between equivalence of height and equivalence of quantity. Note too, that the operation allowed for this distinction. It is clear that S consistently conserved quantity. Of the experimental Ss, 13 out of 20 five year olds consistently (four times) conserved quantity and 16 out of 20 conserved quantity at least once. For the six year olds, 19 out of 20 consistently conserved and all of them conserved at least once. By contrast, the respective figures for the control Ss are 1 and 4 five year olds and 1 and 3 six year olds. Why didn't the control Ss conserve quantity? The following protocol will show the major reason.

Jeffrey, 6-3.
Task M. (Do you now have just as much koolade to sell as ______?) Yes.

Round 2. (Do you now have just as much koolade to sell as ______?) Yes.

Round 3. (Do you now have just as much koolade to sell as ______?) Yes (voluntarily).

Round 4. (Do you now have just as much koolade to sell as ______?) No.

(S puts more in larger part. Why do you think it is the same?) 'Cause they look about the same. (How do you mean?) *The same height.*[4]

Clearly, S is here thinking in terms of equivalence of height and not at all in terms of quantity. It could be argued that S *is* thinking in terms of quantity and that he is simply using a different word for it. This is hardly possible, however, in Task M. When, for instance, S is presented with the situation in Figure 10a, only one thing is equivalent, viz., height of koolade. When E had S stand up and look over the containers, S yet maintained that there was equivalence. In many instances E would ask S to show him what he meant by "Yes." Almost without variation S would gesture to the height of koolade in the intact container and other part, in some cases putting the latter adjacent to the former. Let us look at Jeffrey's protocol on Piaget's task.

Jeffrey, 6-3.
*Task P.* (See Figure 5.)

Comparison #1. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) They're just the same. (Why do you think it's the same?) 'Cause you poured that *water*[5] the same, it was just the same as this (A2) and now it's (A2) the same as that (B1 plus B2).

Comparison #2. That's a big one (L). (Do ______ and you now have the same amount of koolade to drink or do you

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[4]Italics mine. [5]Italics mine.

have different amounts to drink?) I got more than Keith. (Why do you think it's different?) 'Cause it's higher.

Comparison #3. (Do _______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) It's a different amount. (Why do you think it's different?) 'Cause mine is lower (D).

Comparison #4. (Do _______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) I don't have as much as him. (Why do you think it's different?) 'Cause his is higher.

Clearly, S's correct judgment in the first comparison is due to his seeing logical permanence. He is not at all thinking in terms of quantity. In the second comparison (and in the rest that follow) he is thinking simply in terms of height and is overwhelmed by the perceptual illusion (see below).

We see then, that Ss, when asked of quantity many times think only in terms of height equivalence. But Piaget's task necessarily involves change in height with quantity constant. He therefore has further error variance in his measure. Since this is the case, how can Piaget possibly postulate that height (or, "uni-dimensional quantity") is <u>generic</u> to conservation of quantity?

We shall now consider the protocol of a S who took Task P deprived of logical permanence.

Kathy, 12-0.
<u>Task P.</u>

Comparison #1. (Do _______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) Well, it looks like I've got less (A2), but hers (B1, B2) are so much smaller than that one (A2), probably about the same. (Why does it look like it's less to you?) Well, because it (A2) isn't as high and there's two containers over there. (If you had to say exactly, what would you say?) Well, if Janet was in here, I'd say, "You've got more than me." (Why does it look that way?) Well, because this container (B1, B2), since their smaller (circumference), it goes up high when you fill them, and, since that one's bigger (A2), it just doesn't seem as much.

Comparison #2. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) Well it looks like I've got more, but it's probably the same. (If you had to say exactly?) I'd say I have more. (Why?) Because it goes up higher than the other ones (B1, B2).

Comparison #3. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) Janet's got more than I do. She has (S's emphasis) to! (Why do you think so?) Well, because it only looks about half-an-inch high in there (D).

Comparison #4. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) Well I think that in that smaller one (C1) that you've got the same amount as you had in the bigger one (B1), so it seems the same as before and that she's got more.

Here we have an explicit case which points out the problem of the perceptual illusion in Piaget's task. As we have seen, Piaget (1952) himself is cognizant of these illusions and holds that the child must see beyond them in his task. However, a major source of the illusion is found in what we shall call the $r^2$ factor: the square of the radius which makes the change of liquid height vary from container to container. This means that the force of the perceptual illusion varys from comparison to comparison. In Kathy's case, this force is seen to be at work in her first two comparisons and in the third she is overwhelmed by it. And Kathy is twelve years old!

The following are protocols of experimental Ss on Task P.

Pat, 6-4.
Task P.

Comparison #1. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) She has the same as us. (Why do you think it's the same?) She just took her big barrel (A2) dumped it in two little ones (B1 plus B2). And it's still the same ... ..dumped it in little ones, and that's two.

Comparison #2. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) The same. (Why do you think it's the same?) 'Cause, I've just got a big one. We poured my barrel of koolade in a bigger one (L), she poured hers in two little barrels.

Comparison #3. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) We still have the same as Susie. (Why do you think it's the same?) I just got a wider one and bigger (D). Wider, I mean. (How do you know that it's just the same?) 'Cause my big barrel (A2) matched hers (A1). We had the same amount in our barrels and we just put them in, she just put them (it) into those little ones (B1, B2) and I put mine in a great big glass (L) and I put it in the swimming pool (D) and we still have the same amount.

Comparison #4. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) The same. (Why do you think it's the same?) 'Cause she just poured her barrel (B1) into a little one (C1), all of it, and she's still got a big barrel and a little barrel and it's still the same as mine. If she had this one (D), it would be the same amount as ours would be (is).

Teresa, 6-6.
Task P.

Comparison #1. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) It's not a different amount to drink. (Why do you think it's the same?) You just poured that in here (B1 plus B2).

Comparison #2. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) It's not a different amount to drink. (Why do you think it's the same?) Because we just took it and poured it in here (L).

Comparison #3. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) Same amount. (Why do you think it's the same?) 'Cause we just took the tall rocket (L) and put it (koolade) into this (D).

Comparison #4. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) Same amount. (Why do you think it's the same?) Because you took this and put it in this (C1).

It is evident that these Ss clearly see logical permanence and consequently make correct judgments. Of the experimental Ss, 13 out of 20 six year olds consistently (four times) made correct judgments and 15 out of 20 did so at least once. This is in contrast to their controls whose respective figures are 1 and 4. We see therefore that, while there is serious error variance in Piaget's procedure, those Ss who benefited from the learning experience and could see logical permanence succeeded in this task.

We shall now consider another protocol of a S who took Task P deprived of logical permanence.

Jerry, 11-1.
<u>Task P.</u>

Comparison #1. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) I'd say I had more. (Why do you think it's different?) I don't know. (Can you say why?) 'Cause of the size of this (A2). (You mean because it's this way around?) Uh-huh.

Comparison #2. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) I don't know. (Does someone have more to drink?) I don't know, I'd say that Bradd (has more).

(Why do you think it's different?) He's got two of those things (B1 plus B2) and I've only got one (L).

Comparison #3. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) I'd say he had more than me. (Why do you think it's different?) He has two of those (B1 plus B2), he's got more, uh, (You mean his is taller, is that what you mean?) Uh-huh. (Anything else?) And his things aren't as big around as that is (D).

Comparison #4. (Do ______ and you now have the same amount of koolade to drink or do you have different amounts to drink?) I'd say he still had more than me. (Why do you think it's different?) I have a bigger one (D) and . . . well . . . it doesn't have as much koolade in it as the small one does (C1).

We note that S's replies are a replication of those of five and six year old Ss who fail in Task P. They mirror the responses of children whom Piaget (1952) places in stage I. Our position is that eleven year olds who are deprived of logical permanence are looking at the comparisons in Task P from a position that is very similar to that of five and six year olds who do not see logical permanence. This finding would seem to further support that position. It raises a serious question for Piaget, however. If the five and six year olds are responding to the situation in Task P in a similar fashion as that of <u>eleven</u> year olds, what <u>genetic</u> significance can be given to their responses? Piaget attaches great genetic significance to his children's responses: "By grouping the answers to the various questions, <u>it is possible to distinguish three stages</u> (of development)."[6]

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[6]Italics and parentheses mine.

Concluding comments

The evidence therefore indicates that children five and six years of age conserve quantity when given the proper experience. Since they show stability across time in their conserving, the operation is meaningful to them. These findings contradict Piaget's theoretical formulation which asserts that these children are not mentally equipped to conserve quantity.

It is also evident that Piaget is measuring the ontogenesis of logical permanence beyond the perceptual illusion which, as we have seen, is quite different from conservation of quantity.

The findings in this study have widespread educational implications since they show that children in the kindergarten (five year group), with skillful guidance, work with quantity as a meaningful concept. These children did so, furthermore, on the basis of only one special session with E, using geometrical configurations that are fairly complex. While the latter was necessary for our study, this would obviously not have to be the case in an educational setting. With these findings in view one may consider the relation of the concept of quantity to the development of the concept of number in children's thinking. This is a problem for future research.

## CHAPTER IV

## SUMMARY

Piaget's theoretical formulation is as follows: The child's development of conservation of quantity is characterized by three distinct yet inseparable stages. In the first stage the child can think only in terms of gross quantity and therefore is not mentally equipped to understand or grasp conservation. In the second stage the child is capable of logical multiplication in some instances and in others he is not. Yet he is not mentally equipped to understand conservation. Only in the third stage can the child understand the equating of differences and hence discover conservation of quantity.

It is the view of this investigator that children whom Piaget would place in stages I and II can, with a special experience, conserve quantity. This position is contrary to Piaget who holds that these children are not mentally equipped to conserve quantity. It is also our view that Piaget is measuring logical permanence beyond the perceptual illusion, which is different from conservation of quantity.

Control Ss in each of two age groups (five and six years) were given a complex task situation (Task P) that is typical or representative of Piaget's work. These Ss were also given Task M, a measure of conservation of quantity that is independent of Piaget's theoretical formulation. Prior to administering both of these tasks, a neutral task requiring an amount of time comparable to that spent between E and the experimental group was given. Experimental Ss in each of the five and six year groups received a learning experience which focused on logical permanence prior to their taking Task P. These Ss were also given a special experience designed to facilitate the discovery of conservation of quantity prior to their being given Task M, which was followed in one week by a retest on Task M. Ss in an eleven year group were then deprived of logical permanence prior to and during their taking Task P.

The results were that children five and six years of age conserve quantity when given the proper experience and show stability across time in their conserving, thereby indicating that the operation is meaningful to them. It was also found that Piaget is measuring logical permanence beyond the perceptual illusion, which is different from conservation of quantity. The findings have widespread educational implications since they show that children in the kindergarten, with skillful guidance, work with quantity as a meaningful concept.

## APPENDIX I

### EXAMPLES OF PIAGET'S PROCEDURE

**Stage I: Absence of conservation**

Lac, 5-6. (See Figure 13.)

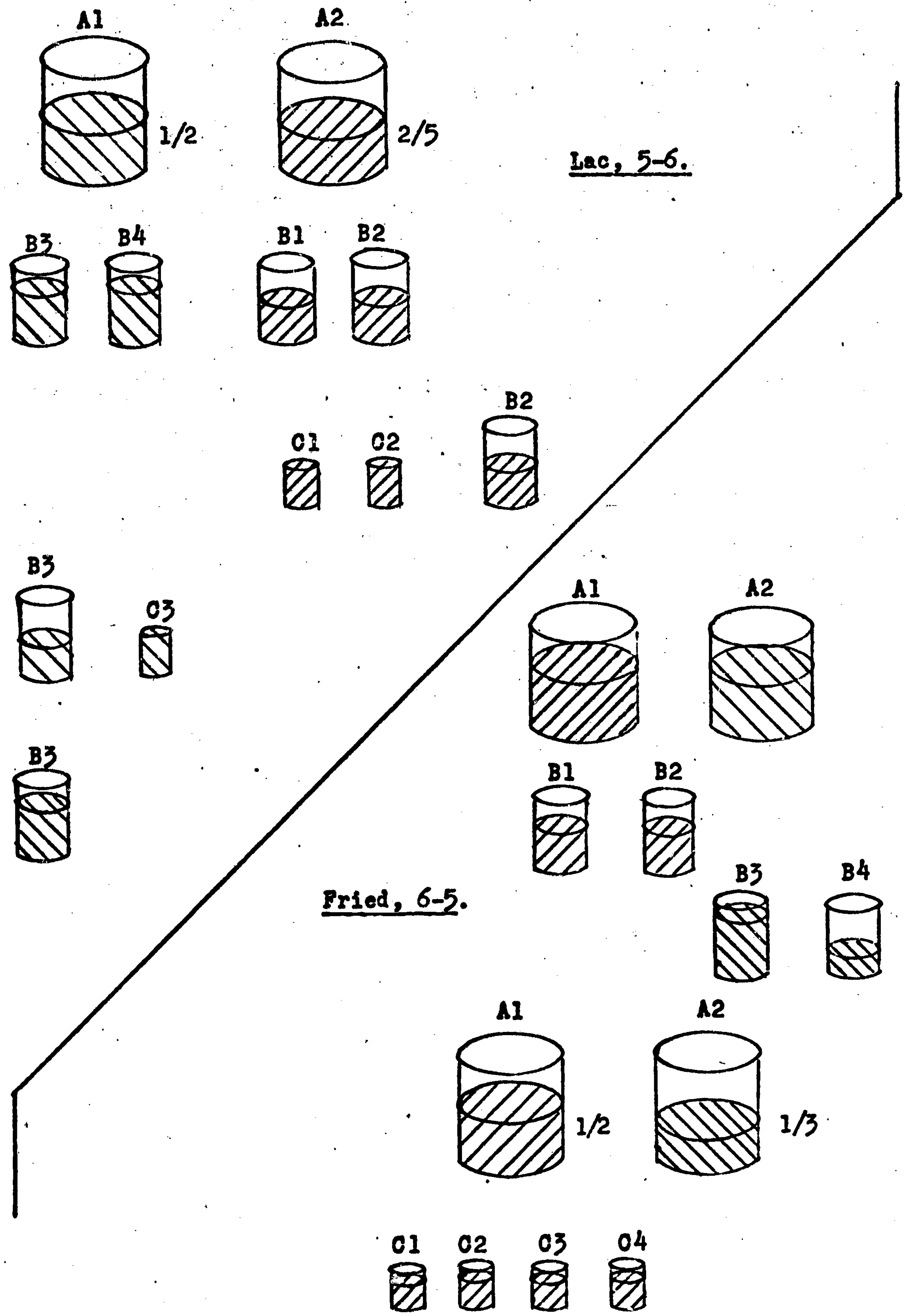
'Here are two glasses (A1 half full of orangeade and A2 slightly less full of lemonade.) The orangeade is for you and the lemonade for Lucien. Lucien is cross because he has less. He pours his drink into these two glasses (pouring A2 into B1 and B2). Who has more? - (Lac looked at the levels) Me. - Now you pour your drink into these two glasses (B3 and B4, the levels being thus slightly higher than in B1 and B2). Who has more? - Me. - And now Lucien takes this glass (B1) and divides it between these two (C1 and C2, which are then full, whereas B2 remains half-full). Who has more? - (Lac compared the levels and pointed to glasses C) Lucien. - Why? - Because the glasses get smaller (and therefore the levels rise). - But how did that happen? Before it was you who had more and now it's Lucien? - Because there's a lot. - But how did it happen? - We took some. - But where? - . . . - And how? - . . . - Has one of you got more? - Yes, Lucien (very definitely). - And if I pour all the orangeade and all the lemonade into the two big glasses (A1 and A2) who will have more? - I shall (thus showing that he remembered the original position). - Then where has the extra you had gone to? - . . . - What could you do to have the same amount as Lucien? You can use any of the glasses. - Lac then took B3 and poured some of it into C3, an empty glass. He filled it, and put it opposite Lucien's C1 and C2. Then he compared B3 to Lucien's B2 and saw that there was less in B3 than in B2. He then took C3 again, poured it back into B3, and then, showing great disappointment, cried: 'But why was it quite full there (C3) and now (B3) it isn't full any longer?'

**Stage II: Intermediary reactions**

Fried, 6-5. (See Figure 13.)

(Fried) agreed that A1 equalled A2. A1 was poured into B1 plus B2. 'Is there as much lemonade as orangeade? - Yes. - Why? - Because those (B1 plus B2) are smaller than that (A2). - And if we pour the orangeade (A2) as well into two glasses (doing so into B3 plus B4, but

Fig. 13.


A1
A2
1/2
2/5
Lac, 5-6.
B3
B4
B1
B2
C1
C2
B2
B3
C3
B3
A1
A2
B1
B2
B3
B4
Fried, 6-5.
A1
A2
1/2
1/3
C1
C2
C3
C4

putting more in B3 than in B4), is it the same? - There's more orangeade than lemonade.' - (B3 plus B4 thus seemed to him more than B1 plus B2).

A minute later he was given A1 half full, and A2 only a third full. 'Are they the same? - No, there's more here (A1). - (A1 was then poured into several glasses C.) It's the same now as there (A2).' He finally decided, however: 'No, it doesn't change, because it's the same drink (i.e. A1 equals C1 plus C2 plus C3 plus C4 and A1 is more than A2).'

## REFERENCES


Braine, M.S. The ontogeny of certain logical operations: Piaget's formulations examined by non verbal methods. Psychol. Monogr., 1959, 73, No. 5 (Whole no. 475).

Dodwell, P.C. Children's understanding of number and related concepts. Canad. J. Psychol., 1960, 14, 191-205.

Elkind, D. The development of quantitative thinking: a systematic replication of Piaget's studies. J. genet. Psychol., 1961a, 98, 37-46.

Elkind, D. Children's discovery of the conservation of mass, weight and volume: Piaget replication study II. J. genet. Psychol., 1961b, 98, 219-227.

Frank, Françoise. Perception and language in conservation. In J.S. Bruner, Studies in cognitive growth. New York: Wiley, 1964.

Inhelder, Barbel. Criteria of the stages of mental development. In R.G. Kuhlen and G.G. Thompson (Eds.) Psychological studies of human development. New York: Appleton-Century-Crofts, 1963.

Lovell, K. A follow-up study of some aspects of the work of Piaget and Inhelder on the child's conception of space. Brit. J. Psychol., 1959, 29, 104-117.

Lovell, et al. Growth of some geometrical concepts. Child Develpm., 1962a, 33, 751-767.

Lovell, et al. An experimental study of the growth of some logical structures. Brit. J. Psychol., 1962b, 53, 175-188.

Lovell, K. and Ogilvie, E. A study of the conservation of substance in the junior school child. Brit. J. Educ. Psychol., 1960, 30, 109-118.

Lovell, K. and Ogilvie, E. The growth of the concept of volume in junior school children. J. child Psychol. Psychiat., 1961, 2, 118-126.

Ojemann, R.H. and Pritchett, K. Piaget and the role of guided experiences in human development. Percept. Mot. Skills, 1963, 17, 927-940.

Piaget, J. The child's conception of number. New York: Humanities, 1952.

Piaget, J. and Inhelder, B. The growth of logical thinking from childhood to adolescence. New York, 1953.

Piaget, J. et al. The child's conception of geometry. Routledge and Kegan Paul, 1960.

Smedslund, J. Development of concrete transitivity of length in children. Child Develpm., 1963, 34, 389-405.

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

Winer, B.J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.

Woodward, M. Concept of number of the mentally subnormal studied by Piaget's methods. J. child Psychol. Psychiat., 1961, 2, 249-259.