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THE UNIVERSITY OF ALBERTA

CONSERVATION DÉCALAGE IN PIAGET'S THEORY

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Conservation Décalage in Piaget's Theory" submitted by Yun Sup Lee in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

The present research was designed to investigate the invariant sequence of conservation dècalage Piaget has observed. Based on 1) a critical examination of Piaget's explanation and use of this phenomenon in his theory of cognitive development; 2) the examination of the research in support of and against Piaget's contention of the dècalage; and 3) a methodological criticism of conservation assessment, the following hypotheses were derived:

H.1. Frequency of Piaget's dècalage pattern among the mass conservers from the age of 6:0 to 7:6 will not be statistically significant.

H.2. The main effect of format of conservation (identity vs. equivalence) will be significant.

H.3. The interaction effect between format of conservation and the type of task (weight vs. volume) will be significant.

H.4. Order of presentation of task will not constitute significant variance.

Mass conservers from the age of 6:0 to 7:6 (N=80) were randomly divided into 4 experimental groups. Each group was given the alternating combination of three experimental

variables (Format x Task x Sequence). Lindquist Type V analysis of variance and X^2-technique were employed for analyzing the data.

The results showed that: 1) Piaget's dècalage pattern does not exist; 2) Format and order of presentation has no effect.

Implications of these findings were discussed in terms of theory and research.

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CHAPTER I

INTRODUCTION

In the area of Piaget's theory of cognitive development, much research on conservation has centered around the effect of certain types of training programs on the acquisition of conservation (e.g. Beilin, 1965; Brison, 1966; Coté, 1968; Frank, 1966; Gelman, 1969; Hall & Kingsley, 1967; Inhelder & Sinclair, 1969; Lefrancois, 1966; Mermelstein, 1967; Rattan, 1970; Sigel, Roeper & Hooper, 1966; Smedslund, 1961; Smith, 1968; Sullivan & Brison, 1967; Towler, 1967; Wallach, Wall & Anderson, 1967). Relatively little effort has been made to investigate the dècalage phenomena, which are directly related to Piaget's stage approach to human cognitive development (e.g. Piaget, 1970 a; Pinard & Laurendeau, 1969). The present research begins with the introduction of Piaget's definition of dècalage.

Dècalage is a French word which means "displacement","separation" or "time lag". In developmental phenomena, this notion may be used to designate certain developmental gaps between cultures or within an individual.

In Piaget's stage theory of cognitive development, dècalages designate the phenomena which "disturb the synchronization between analogous developments" (Piaget, 1970 a, p.1). It means "a downward dropping movement from one plane to another and is used to refer to aspects of cognitive development which appear at a stage subsequent to the one at which they normally are expected" (Inhelder, 1968, p. 31). Piaget (1941, 1954) distinguishes two general classes of dècalages: vertical dècalage and horizontal dècalage. Piaget described vertical dècalage as follows:

> ... dècalages in comprehension refer to passage from one to another plane of activity. For example: from the plane of action to that of representation (Piaget, 1950, p. 330).

> ... the child appears at the onset not to reflect, in words or in notions, the operations which he already knows how to execute in acts and if he cannot reflect on them, he is obliged ... to carry out once again the work of coordination between assimilation and accommodation already accomplished in his previous sensory-motor adaption to the physical and practical universe (Piaget, 1950, p. 317).

Vertical dècalage refers to <u>prima</u> <u>facie</u> similar acquisitions appearing at distinctively different levels of functioning.

> The development of a given conceptual content (e.g. causality, space) is accomplished on several successive levels (sensori-motor, concrete operational, and formal operational) according to an analogical process in which this content,

> already structured at a level established by earlier kinds of actions or operations, is restructured at a higher level by a new kind of operations" (Pinard & Laurendeau, 1969, Pp. 127-128).

During the sensori-motor stage (0-2 years), for example, a child at 8-month-old becomes capable of searching for an object (e.g. watch) which disappears behind an opaque screen. This is the achievement of object permanence, which is the recognition of invariance during the sensori-motor stage. During the preoperational stage (2-6 years) the same child can achieve qualitative identity of an object. For example, in pouring of water, a 4- or 5-year-old, who "maintains that the amount of water has changed, will admit that it is the 'same water', in the sense that the nature of the matter, 'water' has not changed even if the quantity of that matter has changed" (Piaget, 1968a, p.19). This qualitative identity is the recognition of invariance of the preoperational stage. The same child, during the concrete operational stage (7-12 years of age) can affirm the existence of quantitative invariants, for example, amount of mass, weight and volume, based on composition of certain transformations.

On the one hand, the cognitive structures in these three instances have one phenomenon in common, namely, the recognition of invariance. On the other hand, the sequence of change from one level of recognition to the next higher level is also seen as being invariant. That is, the change from functioning on the level of sensori-motor actions: based on direct actions; to preoperations: based on a preoperational logic; to concrete operations: based on a concrete logic is also seen as being invariant.

Another example of vertical dècalage is that the heterogeneous objects (e.g. conservation of continuous quantity vs. that of discontinuous quantity) sometimes give rise to "slight dècalages" explainable "by the difference in perceptual or intuitive conditions" (Piaget, 1941, p. 266, in Pinard & Laurendeau, 1969, p. 131).

For the horizontal dècalage, Piaget gives the following description:

> ...horizontal dècalages occur at a common level of development but between different systems of actions or ideas. For example: conservation of the notion of quantity of material before the conservation of the notion of weight, where the same groupments of actions are in play (simple addition or variants of parts) but which are applied to qualitatively different contents (substance and weight) (Piaget, 1941, p. 263 in Inhelder, 1968, p. 32).

Horizontal dècalage refers to a repetition which takes place within a single functional level of vertical dècalage. It is horizontal because it occurs within one stage. It is dècalage because it "expresses a chronological difference between the ages of acquisition of operations that bear on different concepts (or contents), but obey identical structural laws" (Pinard & Laurendeau, 1969, p. 130).

The classical example of this horizontal dècalage is the recognition by a child during the concrete operational stage of the invariance of the amount of mass, weight and volume. According to Piaget (1956, 1957, 1968 a), from seven to eight years of age onwards conservation of mass is felt as a logical necessity and is supported by relevant arguments. These same children, however, deny the conservation of weight for reasons similar to those they used when under seven to deny the conservation of mass. At nine to ten years they admit the conservation of weight, and by way of proof they use arguments similar to those formulated for explaining the conservation of mass. These same children again deny, at this age, the conservation of volume for the same reasons they had formerly used to deny the conservation of mass and weight. Finally, when they are 11 to 12 they affirm the conservation of volume and give appropriate arguments to support their judgements.

In summary, the horizontal dècalage refers to a differentiation of different kinds of conservation concepts, whereas vertical dècalage refers to a progressive differentiation of the various domains of application of the operations in the process of establishing themselves. Piaget (1941 p. 270) concluded that "the horizontal dècalages express the differences of speed between the vertical dècalages of distinct concepts" (in Pinard & Laurendeau, 1969, p. 132).

As was implied in the above description, dècalage in Piaget's theory of cognitive development means the chronological differences required for the natural emergence of certain qualitatively different functions or for the natural, sequentially invariant acquisition of certain concept conservations as a function of age.

This study addresses itself to the study of the notion of dècalage with respect to the conservation of mass, weight and volume.

What are the major factors and variables which, in the daily life experiences of a child, determine this invariant sequence if it exists?

What are the psychological processes which are responsible for the sequence, if it exists?

Does this invariant sequence really exist?

This study takes the last question as its line of departure, since the last question is basic to the other two questions.

The second chapter examines Piaget's explanation of the horizontal dècalage. It reviews experimental evidence in support of or against Piaget's contention, which leads to the major hypothesis of this study, while methodological criticism leads to the minor hypotheses. Included also is a brief review of the relationship between some demographical variables and conservation. An overview of the experimental procedures comprises the third chapter. The fourth chapter is concerned with the analysis of data and the fifth chapter consists of discussions of results and of their implications.

CHAPTER II

REVIEW OF LITERATURE

Piaget's Contention

Piaget has observed that a seven-year-old child can conserve the invariance of quantity in front of perceptual perturbations (e.g. Piaget, 1950). This conserving behavior is said by Piaget to be based on a system of operations which is characterized by nine groupings (for details Piaget, 1957 a; Beth & Piaget, 1966). This system of operations which defines the cognitive structural law of the concrete operational stage is hypothesized by Piaget to support or explain the acquisition of conservation of all kinds, such as number, area, length, mass (substance, matter, global quantity), weight, volume, etc. Piaget has reported that there is an invariant developmental sequence of mass, weight and volume, mass conservation being achieved first (age about 7 years) and volume last (age about 12 years). Piaget reported the same results when he used a number of different techniques. The dècalage phenomenon was also reported in his transitivity study. Piaget (1957 a, p. 17) wrote:

> But curiously enough, with respect to all the operations, one finds exactly the same lack of correspondence. For example, children from seven to eight onwards are able to order serially objects according to length or size, but it is not until about 9 to 10, on the average, that the serial ordering of objects by weight becomes possible.... From seven to eight children become aware of the transitive character of equalities in the case of lengths, etc., but only towards 9 to 10 in the case of weight and towards 11 to 12 for volume.

By applying this developmental dispersion of mass, weight and volume, Piaget concluded that "thus, up to the age of 11 or 12, a particular logical form is still not independent of its concrete content" (Piaget, 1950, p. 147). "Because of this, concrete operations fail to constitute a formal logic; they are incompletely formalized since form has not yet been completely divorced from subject matter" (Piaget, 1957 a, p. 17). This invariant sequence of conservations marks the onset and the end of the concrete operational stage. Piaget gave three explanations of this genetic succession of conservations.

First, this succession comes under the law of logical implication (Piaget & Inhelder, 1947, p. 403).

> Conservation of physical volume always implies conservation of matter. Those three elements which at first are indistinguishable, slowly differentiate themselves, following both experience and the child's own development, so as to integrate into one another in an order of constant succession.... The presence of such a genetic succession of notions, each of them typical

> of true logical construction shows us an example of a scale of development which would enable us to place abnormal phenomena of feeble-minded reasoning at a stage of mental evolution.

For the sequence, Bärbel Inhelder (1968) was able to show that the order of acquiring the concepts of conservation of mass, weight and volume recurs in its entirety in mental deficiencies; the last of these three constants (present only in slightly backward individuals and unknown in really deficient cases) is never found without the other two, nor the second without the first, while conservation of mass occurs without conservation of weight and volume, and that of mass and weight without volume (Piaget, 1950, p. 154).

It is unclear what Piaget means by his term "logical implications". Perhaps, Piaget might think that weight can be defined by mass, and volume can be defined by matter and weight. In Newton's world of physics, all matter possesses two properties, gravitation and inertia. The gravitational mass of a body could be determined from the force of attraction exerted on the body by the standard body. For example, to compare the gravitational masses of two bodies, the forces with which the earth attracts them at any one point on the earth's surface could be compared. Thus the gravitational masses of bodies can be compared by simply weighing the bodies. In the inertial mass, mass is the quantitative or numerical measure of a body's inertia, that is, of its resistance to being accelerated. The inertial mass of a body is equal to its gravitational mass. In general, mass is defined in terms of inertia but is measured by weighing. Besides, mass is lineally additive and is conserved, that is, it can neither be created nor destroyed.

In Einstein's world of physics, the inertia of a body should increase if the energy of the body increases. The mass of a body can be changed not only by cutting a part of the body off, for example, but by merely changing the body's energy. Mass is no longer additive (McGraw-Hill Encyclopedia of Science and Technology, 1960, Pp. 161-163).

The weight of a body is the force with wh'ch the earth attracts the body. This force is proportional to the body's mass, and depends on the location. Since weight is a force, it is expressed in force unit such as gram or pound. To distinguish it from the mass unit, gram (pound) force is used for mass unit and gram weight for weight unit (McGraw-Hill Encyclopedia of Science & Technology, 1960, p. 461).

Volume is defined as the space occupied by any body. It is definite for any specific temperature and pressure. The metric units of volume are the cubic centimeter and the liter (International Encyclopedia of Chemical Science, Van Nordstand Reinhart, 1964, p. 1205).

From the above examination of the relationship among the three concepts in concern, there does not seem to be a hierarchy such as, most probably, Piaget's term, "logical implication", means. Operationally, therefore, definition of volume does not require definitions of mass and weight. Furthermore, in ordinary sense, the concept of mass and that of weight are the front and back side of one coin. Furthermore, the concept of mass is more difficult to understand than that of weight and volume in the sense that Newtonian inertial mass requires the measurement of acceleration and Einstein's mass requires the understanding of the concept of energy.

Piaget's conservation approach to concept assessment has no relationship to the understanding of a concept as such. For example, to solve mass conservation does not mean the understanding of the definition of the concept of mass as such, in its Newtonian or Einsteinian sense. The conservation procedure is related only to the same amount of quantity, regardless of its content such as mass, weight, volume, number, etc. Then, why should the conservations of these three concepts appear in invariant sequence as Piaget contended?

Piaget has given yet another explanation of this conservation dècalage. "The reason for these separations is naturally to be sought in the intuitive character of substance, weight and volume, which facilitate or hinder operational combinations" (Piaget, 1950, p. 147).

What is the intuitive character of mass which facilitates conservation of mass at the age of seven where that of weight or volume hinders conservation? Piaget did not answer this question. An examination of the way Piaget defined these three concepts and the techniques used for assessing them may clarify this intuitive character. In his classical experiment of conservation of mass, Piaget asked his subjects whether "the amount of clay" remains the same after a certain transformation (e.g. to a sausage shape). In this case, it is unclear what the subjects are responding to. Mass as such is not quantifiable. Children may quantify the "amount" of clay in their own way. Piaget also recognized these delicate aspects. He wrote:

> In the specific case of conservation of matter, I see two problems. First of all, this matter supposedly is conserved by the child before weight or volume is a reality which can be neither perceived nor measured. What is a quantity of matter whose weight and volume vary? It is not something accessible to the senses: It is pure substance. It is very interesting to see how the child starts with the notion of substance... before arriving at conservations verifiable by measurements. Actually the conservation of substance is empty form (1967, Pp. 153-154).

Since in Piaget's use of the term, "form" means a certain form of logical thinking, his term "empty form" may mean that a child who responds that "the amount of clay has not been changed" in the face of certain transformations does not take the form of the concrete operations which is hypothesized by Piaget himself to explain all kinds of conservation behaviors, including mass conservation. If this is what he means by the term, "empty form", then mass conservation would be possible without basing itself on the concrete operations, which is clearly contradictory to Piaget's theory of cognitive development.

If his term "empty form" means that conservation of mass is not "verifiable by measurement", then it is not conservation since according to Piaget (1968 a, p. 19):

> Conservation is possible only when there is composition of quantitative variations which can take the form of a compensation of relations (higher x thinner = the same amount) or simply of an additive composition (nothing added, nothing taken away = the same amount).

Then, Piaget may mean that mass conservation is an example of qualitative identity response. In qualitative identity response,

> ... the invariant is obtained without quantitative composition; there is simply a dissociation between a permanent quality (the same water, the same me) and the variable qualities (the shape or size), but there is no composition of these variations (Piaget, 1968 a, p. 19).

Considering that qualitative identity comes earlier than conservation, as was demonstrated by Bruner (1966) and Piaget (1968a), this may account partially for the earlier emergence of mass conservation in the sequence. However, Piaget does not accept qualitative identity response as indicating conservation. To him, this qualitative identity conservation should be a quantitatively-based response. As Braine (1962, p. 46) has said: "The child presumably responds to the 'meaning' he attributes to experimenter's words. What these 'meanings' are we do not know....".

In assessing volume conservation, Piaget used two approaches; interior volume and occupied volume.

> ... around the age of 6:6 or 7:6... children work out the relations between the three dimensions... using only logical multiplication, that is, without measuring or making more exact compensations based on a unit system.... Such conservation exists only in regard to 'interior volume', in other words the subject recognizes the invariance of the amount of matter which is contained within boundary surfaces (1960, Pp. 359-360).

In other words, this conservation of interior volume is achieved approximately at the same time as that of mass, area, and length. Moreover, in the case of 3 x 3 x 4 unit metal cubes, conservation of interior volume is confounded with that of number and/or that of mass, i.e., invariance of the amount of mass. What Piaget asked his subjects when he studied the horizontal dècalage, is not this kind of volume, but occupied volume, meaning the amount of space occupied by the object as a whole in relation to other objects round about (e.g. water). In Piaget's assessment of this occupied volume by using 3 x 3 x 4 unit metal blocks, Piaget emphasized measurement aspects, which he calls "schema of proportion", or multiplicative compensation. Piaget wrote (1960, p. 385):

> Because interior volume can be measured and calculated from now on, its invariance now extends to surrounding space. This explains why the conservation of occupied volume (in the sense in which the concept is understood by the physicist) is not achieved until the level of formal operations, for it is only now that interior volume can be measured by virtue of the new found concept of metrical continuity.

It seems unreasonable to the present writer that it takes five or six years to extend the invariance of interior volume, which is said by Piaget to appear at the age of seven, to the surrounding space such as water, which can be achieved only at the end of the concrete operational stage.

Elkind (1961 b, Pp. 555-557) asked and discussed the question "why significantly more students attain abstract conceptions of mass and weight than attain the abstract conception of volume?" His discussion took for granted Piaget's contention of the sequence, based on his previous experiment (1961 a), which will be discussed in the following section, and attributed the late emergence of volume conservation to the non-intellectual variables such as new interest or the attenuation of drive for conceptualizing the immediate physical environment.

> The adolescent is no longer content to live the interindividual relations offered by his immediate surroundings to use his intelligence to solve the problems of the moment. Rather he is motivated also to take his place in the adult social framework... (Inhelder & Piaget, 1958, p. 341).

In the adolescent period, "this attenuation of drive for inductive conceptualizing therefore decreases the possibility of children spontaneously discovering the conservation of volume" (Elkind, 1961 b, p. 556). This explanation is <u>post hoc</u>. Why does this non-intellectual factor of the adolescent period invoke the late emergence of volume conservation only? Why not mass or weight conservation? Furthermore, Piaget's logical analysis of the concept of volume does not necessarily show the sequence of development. For example, Piaget, Inhelder and Szeminska (1960, chapter 14) contended that the concepts of continuity and infinity, and of compression-decompression of mass are prerequisites for volume conservation. Lunzer (1960) found that the concept of infinity was not mastered prior to nor even concurrently with volume conservation. He concluded: "the logical complexity of conceptual structures (of a concept) does not operate directly on the process of acquisition which they exhibit" (p. 201).

Piaget gave the third explanation on this conservation dècalage in terms of the relationship between concrete operations and the respective conservations, which appeared in Piaget and Inhelder's work, Le Dèveloppment des quantites chez l'enfant (1941, not translated). Flavell (1963, Pp. 298-303) summarized Piaget's explanation as follows:

> What prevents the child, once in possession of these intellectual tools from immediately extending the invariance of matter to that of weight and volume? In the case of weight, subject protocols suggest the following difficulty (ibid., Pp. 36-40). Egocentric prenotions about the nature of weight (weight is the sensation of pressure on my hand when I hold an object, etc.) seem to pose a specific obstacle to the conservation of weight, even when the child is fully in possession of the schemas necessary for conservation of matter. .....
> The conservation of volume is a late achievement because, ... the requisite schemas relating to density and compression-decompression of matter are themselves late achievements.

However, the present writer fails to understand why ego-centric nature of weight intervenes here. Why only in weight? Mass also has this kind of ego-centric nature. For example, mass of sugar is the sensation of taste, or mass of clay is the sensation of touch when a child plays with it.

For volume, some comment was made when Piaget's second explanation of the dècalage was discussed. A more important question in this context is whether there is any relationship between concrete operations as such and conservation.

According to Piaget (1957 a) "when the most elementary forms of conservation are absent, it is a consequence of the absence of operational reversibility (p. 12)".

Bruner and his colleagues (1966, Pp. 184-186) have argued that reversibility is not at the heart of the conservation problem. Piaget (1968a, 1970 b) has responded that Bruner has confused reversibility with "empirical return" without awareness of underlying process.

Piaget (1957 b, p. 44) offers the following definitions (translated by Berlyne, 1965, Pp. 222-223).

> We shall call 'reversibility' the capacity to carry out one and the same action in both directions, with an awareness that it is a matter of one and the same action... we shall say that an action is 'revertible' or that there is empirical return to the starting point when the subject comes back to the latter without an awareness of the identity of the action carried out in both directions.

It seems to the present writer that the difference between reversibility and revertibility is whether a child can justify verbally the conservation response he made. The question the present writer asked here is the role of reversibility in conservation. Is reversible operation logically and psychologically a cognitive inferential variable in understanding the concepts of mass, weight, volume? Logically, reversibility does not give any information about the concepts such as mass, weight and volume. Psychologically, it is irrelevant to conservation because, as was shown in

Murray & Johnson's study (1969) non-conservers gave evidence of reversibility.

> ... on purely logical grounds the reversibility of the transformation is irrelevant to the conservation judgment since it provides no evidence that the property of the object in question did not, in fact, change while it was in the transformed state. That ... a clay pancake can be returned to its original state as a quantity of water or as a clay ball is no guarantee at all that its volume, etc., as ... pancake was the same as its volume, etc., as a quantity of water or as a clay ball. Because a stretched rubber band can be returned to its original shorter length clearly does not mean that it was not longer when it was stretched. When the child offers a reversibility reason to justify a conservation response, his argument is irrelevant and, strictly speaking, incorrect. (Murray & Johnson, 1969, p. 285)

Piaget (1970 a, Pp. 5-7) has suggested three reasons for dècalage which might suggest the approach to studying this problem. First, he recognized that "such factors as interest, concreteness of the questions, etc., play an obvious role and often there is a dècalage between,for example, the results of rigorously standardized interrogations and those of free interrogations". In other words, he recognized that the experimenter's approach to the problems may account for some part of this dècalage.

The second explanation is that "the material influences the resistance which has to be overcome, and the effect, though unpredictable, can vary considerably from one situation to another". If this is the main source of dècalages, "they are naturally spread out over much shorter durations (i.e. across the substages of the same period, or sub-period)..." (Pinard & Laurendeau, 1969, 134-135).

The third reason is that "... the object exists independently of him and because this independent existence is revealed in a series of causal reactions which are more or less understood by the subject". The present writer could not understand the precise meaning of this sentence. Probably it means that experience with the object in question may account for this dècalage. However, this does not constitute the reason for the invariant developmental asynchronism.

In summary, 1) There is no logical hierarchy among the concepts of mass, weight, and volume, such as, most probably, Piaget's term,"logical implications" means.

2) Conservation approach to concept assessment in general, does not mean the understanding of the definition of a concept as such.

3) Piaget's interpretation of mass conservation is contradictory to his own theory.

4) It seems that Piaget's analysis of the concept of volume does not operate directly on the process of acquisition.

5) Logically, concrete operations do not give any information about the concepts (such as mass, weight, volume).

6) It seems that psychologically reversibility is irrelevant to conservation, since non-conservers understood the reversibility.

In general, Piaget's explanations of the conservation dècalage are post hoc ; none of them is convincing. Where could we find the convincing explanation of the conservation? Is it ever possible to prove the invariance sequence of acquisition of the conservation concept? These questions will be discussed in the last chapter.

The next section will summarize the relevant researches which either support or conflict with Piaget's contention of horizontal dècalage.

Experimental Evidence

In general, horizontal dècalage has been confirmed by a number of studies. However, researchers have noted that conservation judgements are partly dependent on specifics of the task.

In his replication study, Elkind (1961 a) confirmed this conservation dècalage. One hundred and seventy five children of middle or upper middle class, from age 5:8 to 11:9 served as subjects. The mean IQ for the five oldest age levels was 109 on the Kuhlmann-Anderson Intelligence Test (SD=11.0). Using clay balls as material, subjects were asked to predict, judge and then explain their conservation or non-conservation responses (Type of Responses). The order of the questions and the order of presenting of quantities-- mass, weight and volume-- were fixed as in Piaget's original experiment. Results showed that Type of Response was non-significant, whereas Type of Quantity yielded significant F value (F obs.=255.55, $p < .01$). Individual t-tests confirmed the difficulty level of mass, weight, and volume conservation to be in an ascending order. Age level was also significant (F=14.38, $p < .01$). Quantity-age level interaction constituted the significant variance, which confirms the existence of conservation dècalage. One interesting result is that only 25% of 75 responses on the conservation of volume question at age 11 (N=25, three types of responses) showed conservation responses (Table 1, p. 223), whereas 92% for substance and 78% for weight were obtained at the same age level. Elkind (1961 b) investigated this discrepancy. Four hundred sixty nine junior and senior high school students from 12 to 18-year-old groups were tested. Only the oldest group (age 17-18) reached an above 75% of success rate. As a whole, only 47% had an abstract conception of volume, whereas 87% had those of mass and weight. In college students (Elkind, 1962), only 58% had an abstract conception of volume.

Ten years later, Towler and Wheatley (1971) replicated Elkind's findings with college students. They showed that only 61% of the 71 female subjects (median age, 18) in a mathematics course adequately formed concepts of volume. This finding was very close to the 58% figure for Elkind's subjects. If we applied the criteria of 75% achievement, then at age 18, the conservation of volume could not be achieved by even mathematics students. Then why should this kind of question be asked of a child much younger?

Piaget (1969) commented on Elkind's (1961 a) result on volume conservation:

> This last result... is to be explained by a slight difference in technique; he (Elkind) himself asked whether the two objects (ball and sausage etc.) took up the same amount of space in the water. When the question is worded (as ours was) in terms of displacement of water level, the problem is more quickly solved (p. 160).

Piaget here indirectly admits that slight changes in the form of questions may influence the results.

Uzgiris (1964) studied situational generality of mass, weight and (occupied) volume conservation. Twenty children (10 male, 10 female) from each of the first through sixth grades served as subjects. Materials such as plasticine balls, metal nuts, wire coils, straight pieces of rod, plastic-insulated wire were used. In general, the three conservations were almost invariably achieved in that order for each of the five types of material. However, the individual position on this sequence is not constant across materials. "This variation does not seem to be systematic" (p. 839). Conservation of weight, for example, appeared at first grade (mean age 6:11) in plasticine, metal, and wire (10%-20%). The result of volume conservation is noteworthy. Only 20% or 30% of 6th graders conserved volume, not much improvement from the second graders (10%-15%). This result agrees with that of Elkind (1961, a, b). Lovell and Ogilvie's (1960, 1961, a,b) studies of conservation generally confirmed the sequence, using clay balls. However, there were some points which were not supporting Piaget's observation. Lovell and Ogilvie concluded that even in mass conservation, about one-third of those who were non-conservers in the experiment involving plasticine were conservers in the experiment involving the rubberband (1960). Furthermore, a few children actually appealed to weight invariance in justifying their mass conservation responses. In their weight conservation study, they showed that weight conservation judgement may be importantly influenced by the kind of transformations performed upon the materials; many children who recognized that the weight of an object is not altered when its shape changes still believe that making harder or softer would change the weight (water cooled until it turned to ice, hard butter allowed to soften etc.). In their volume study (1961, b) conservation of occupied and displacement volume appeared at first grade, contrary to Piaget's contention. They concluded (1961, b, p. 39):

> It seems that Piaget et al. are optimistic if they think that the single test, in which they employed 36 unit cubes in a bowl, will enable them to distinguish between those who have developed a complete concept of physical volume from those who have not.

In general, the above studies confirmed Piaget's contention of conservation dècalage. However, this confirmation was based on "dominant features" at certain age levels. It seems to the present writer that Piaget himself does not like this appeal to "dominant features". He once criticised Freudian stage theory by this term, "dominant features". According to him, "there is no reason why the anal stage does not come earlier than the oral stage. Stages in Freudian theory are based on 'dominant features without integration'" (Piaget, 1956, p. 13). By the same token, confirmation of conservation dècalage by "dominant features" (% score at certain age) is the weakest support to conservation dècalage.

Cross-cultural studies also generally confirmed this dècalage. Goodnow (1962) compared the performances on conservation of area, weight and volume by European (N=148) and Hong Kong Chinese children (Higher SES N=51, Lower SES with full schooling N=80, Lower SES with semi-schooling N=80) from the age of 10 to 13. Results showed that the sequence of weight and volume conservation was constant across cultures.

The result of Hyde's cross cultural study (1970) is interesting to report (Aden, South Arabia). Among 144 subjects (half male, half female, European 48, Arab 48, Indian 24, Somali 24) from age 6 to 8, 40 subjects conserved one or more concepts (31 European, 10 Arab, 5 Indian, 3 Somali). Of these, 21 subjects supported Piaget's hypothesis of the invariant sequence and 25 subjects did not (read from Table 4, p. 98). She wrote:

> All the evidence appears to invalidate hypothesis 3 (horizontal dècalage) with reference to the concepts of substance, weight and volume, but not, if order is ignored, the fact that some basic concepts are acquired with greater difficulty than others. The main problem is how it will ever be possible to <u>prove</u> invariable sequence of Piaget's stages of cognitive growth when so many variables are involved in the test situations (p. 101).

The most recent attempt to review this within-stage asynchronism was made by Hooper, et al. (1971). They generally agreed that although the conservation of mass, weight and volume seems to be attained in the invariant sequence with any material, there is not a perfect coordination of steps in the conservation sequence across different materials in any one individual (Hooper, et al. 1971, Pp. 6-12). They concluded that "most of children acquire the relevant concepts or task abilities in the predicted order of acquisition but that a <u>universally</u> invariant sequence is not unequivocally substantiated" (p. 70). They suggested that the response patterns and underlying cognitive functioning of the individuals who deviate from the general acquisition sequence merit considerable study and examination (p. 70). The basic problem is to confirm or disconfirm the existence of Piaget's dècalage pattern.

Methodological Criticism

Methodological criticism on Piaget's original experiment will lead the present investigation to the specific experimental procedures. The following aspects will be discussed:

(1) methodological differences between identity and equivalence conservation;

(2) verbal factors in Piaget's experiment;

(3) testing procedures.

Identity vs. equivalence conservation

Elkind (1967) pointed out that Piaget's discussion of conservation which means the equation of differences, refers to the compensation of changes within one and the same object. However, what Piaget assessed was exclusively the equation of differences based on two identical objects. The former was called "conservation of identity" and the latter was called "conservation of equivalence". Schematically,

Conservation of identity	Conservation of equivalence
SINGLE PARADIGM	PAIRED PARADIGM
V ⟶ V'	S = V
V ? V'	V ⟶ V'
	V = V'
	S ? V'

where S stands for standard object

V stands for variable object

V' stands for transformed variable object.

As can be seen from the above paradigm, conservation of equivalence covertly required a transitivity operation as a prerequisite condition; S=V, V=V', therefore S=V'.

Piaget wrote:

> First of all, it is clear that the child would have no means of gauging the equality or non-equality of the various quantities... if he were merely asked to compare them. The fact that the liquid is poured from one container into another does, of course, suggest equality but... this action is not sufficient to explain conservation, since the younger children think that the change in shape involves a change in quantity (1952, p. 22).

Elkind (1967) gave two reasons why Piaget used this equivalence task as the assessment tool of conservation.

> From the practical point of view, the test of identity conservation runs the risk of memory falsification.... The theoretical reason would seem to lie in Piaget's assumption that identity and equivalence conservation is also the age of identity conservation, so that it is legitimate to infer the age of the latter from the age at which the former is attained (p. 23).

It seems to the present writer that this memory falsification, if any, is also present in the conservation of equivalence, as was shown in the bracket. Furthermore, the presence of a standard object may pose an additional problem in the study of conservation.

Vinh Bang (Elkind, 1967, p. 21), for example, gave both children and adults a ball and a sausage of clay and asked his subjects to equate them in weight by adding or removing clay from the ball in weight. At all age levels subjects made the sausage much too small to equate them in weight. If this is true, then with respect to weight, the equation of differences cannot of itself explain the child's judgement that S=V'.

No data is available on volume and mass. However, some indirect evidence is available.

Poteat and Halsebus (1968) showed that twenty five 5-and 6-year-old preschool children, when asked to choose between geometric solids, selected as "bigger" those objects having greater verticality, significantly different from those of a control group of 25 college freshmen. Lunsden and Poteat (1968) again showed the bigger figure to be the one having the greater value dimension, even when the surface area of the less vertical figure was 4 times as great, significantly different from the selections of a control group of 35 high school seniors. However, it is not clear whether this confounding factor plays a role in seven to twelve years old's judgements of conservation.

This paper does not address itself to the investigation of a certain illusion which may hinder the acquisition of conservation of volume. Goldschmid (1967) suggested that elongation may be the dominant misleading cue. The single format may get rid of some "uncertain" illusions which might play a role in the paired paradigm. Furthermore, there is evidence that this identity conservation comes earlier than that of equivalence.

Bruner (1966, p. 183-192) discussed this aspect.

> ...we agree with his (Elkind, 1965) general point that not only are the two concepts different on an abstract level, but each requires a separate form of operational definition. The usual way in which conservation studies are carried out permits no proper inference to be made about the two notions, identity and equivalence.

By quoting Nair's duck experiment, Bruner concluded that "It seems fair to conclude tentatively that a recognition of identity is a necessary if not a sufficient condition for the recognition of quantitative equivalence".

Hooper (1969) employing an independent measures design, studied this conceptual distinction between identity conservation and equivalence conservation. Kindergarten, 1st and 2nd grade levels (16 male and 16 female at each level) were assessed under two formats. The experimental task was limited to the conservation of continuous quantity. The results showed that under the paired format, 9.1, 54.2 and

66.7% of kindergarten, first and second grade sub-samples passed equivalence conservation, whereas 50, 75 and 75% for the kindergarten, first and second grade passed identity conservation. While all these differences favor the identity conservation case, only the comparison for the kindergarten subjects is significant ($X^2 = 8.026$, df=1, $p < .01$). The differences between identity conservation and equivalence conservation shows up most clearly in the results for male subjects:identity conservation performance is uniform (83.3%) for all three age grade levels, but performance in equivalence conservation increases sharply from the kindergarten (8.3%) to the first grade (67.7%) to the second grade (91.7%). The categories of explanation given by the subjects deserves special attention here. Under the single paradigm, the appeal to addition-subtraction (50.8%) and compensatory relations (25.4%) was dominant, whereas under the paired paradigm, references to the previous state (70%) and compensatory relations (17.4%) were dominant. He concluded that "Piaget's view of identity and equivalence conservation cannot be adequately assessed in the conventional paired stimulus format" (P. 234).

Schwarts and Scholnick (1970) assessed the effect of the stimulus situation on the conservation of identity and equivalence among 40 subjects attending nursery schools and kindergartens. The experimental demand made was to judge non-verbally which glass had more when candies were poured from one glass to another. The results showed that when the two containers differed in diameter, equivalence judgements were more difficult than judgement of identity, which supported Elkind's distinction.

Northman and Gruen (1970), briefly reported that the hypothesis that a significant number of subjects show evidence of identity conservation in the absence of equivalence conservation was not substantiated by the results. Three identity conservation and three equivalence conservation tasks were administered. (The kinds of conservation were not reported). The results indicated that most children conserved in an "all-or-none" fashion, that is, most subjects conserved either on almost no trials or on virtually all trials.

Taking the above experiments together, it seems to the present writer that for the younger children, identity conservation precedes equivalence conservation and for the older children these two formats do not differentiate the conservation assessment. The effect of these two formats of conservation will be investigated.

<u>Verbal Factors in Piaget's Experiment</u>

Another important factor is that Piaget's experimental procedures were heavily dependent upon verbal abilities of subjects.

Braine (1962) charged, perhaps overcritically, that Piaget's tasks are measures of verbal fluency. The "more", "same", and "less" are the critical words in Piaget's experiment. The word "same" is required as correct response of conservers, across conservation tasks. However, the word "same" may mean "look alike" (similarity of appearance), rather than "really alike" (similarity of criterial attributes) (Braine & Schank, 1965), or may mean identity or equivalence (Elkind, 1967).

Griffiths et al., (1967) showed that the nursery school subjects were correct more often in their use of "more" and "less" than in their use of "same" for length ($p < .05$) and weight ($p < .01$) comparisons. The term "same" and "less" were more often elicited than spontaneous for weight.

Lunsden (1969) reported that training, directed toward learning the concept of "bigger" among 4-7 years olds significantly influenced the incidence of size conserving responses and a post test of the adequacy of the "bigger" concept revealed a significant difference, compared to the control group.

Donaldson and Balfure (1968) also reported that "more" was dominant as the interpretation given to the undifferentiated pair and "less" remained largely undifferentiated, among 4-5 years olds.

Nummedal and Murray (1969) reported that the performance of 27 first graders and 30 second graders was analyzed on eight connotative-denotative discrimination problems and seven conservation-of-weight problems, each of which represented physical dimensions (wider, narrower, longer, shorter...etc.) that are highly correlated on the semantic differential potency factor. The results indicated that subjects who made correct denotative discriminations performed significantly better on the conservation of weight problems than subjects who were unable to discriminate connotative from denotative meaning. Of the 13 subjects who failed to discriminate connotative and denotative meaning, 3 were conservers and 10 were non-conservers. This may suggest that the general ability to make denotative discriminations may be acquired prior to the ability to conserve weight.

Sinclair-de Zwart (1969) examined the relationship between children's language and conservation behavior. She compared children's performance in conservation of liquid tasks to their use of such differentiated terms as long, short, thick, and thin used to describe pencils that varied in length and thickness. She found that while 100% of the children who conserved used different terms for different dimensions, undifferentiated terms were used by approximately 75% of the non-conserving children, i.e., they used the same word to refer to two dimensions; e.g., fat for long and thick, or small for short and thin.

Farnham Diggory and Bermon (1968) reported similar language-conservation relationships. The relationship between the role of language and conservation is still at issue between the Geneva group and non-Genevan groups.

For the present research, the contaminated terms such as "more", "same", "less", "heavier" will not be used. Instead, "where is the hand (of the scale) now?" or "where is the water level now?" will be used.

Testing Process

Piaget himself did not specify the exact experimental procedures. His original experiment is available from Elkind (1961a), Hyde (1970), and Goldschmid and Bentler (1968). For the methodological criticism, Goldschmid and Bentler's Concept Assessment Kit-Conservation will be used, since it is based on Piaget's original experiment and gives us a full view of testing procedures. For testing the conservation of mass, the test goes as follows:

Directions	Verbal Instructions
(I)	
Make two equal balls of play dough (each 3 oz.), saying:	Here are two balls of play dough. There is the same amount of play dough in each ball. They are both alike. Is there as much play dough in this ball as in that one, or does one have more?
If the subject says they are both the same, go on to (II).	
If the subject says one ball is larger, say:	Let's make them the same. I am taking a little bit away from this one and adding it to that one. Now, is there as much play dough in this one as in that one?
Continue to adjust the two balls until the subject says they are the same.	
(II)	
Roll one ball into a hotdog (6 inches long--use ruler), saying:	Now, watch what I do. See, I am making this ball into a hotdog.
When finished, ask:	Now, is there as much play dough in this one, as in that one, or does one have more?
Record and ask:	Why?
Record.	

The noise factor due to the ambiguity comes into play right at the starting point in the testing procedures. The experimenter may make two balls of play dough equal in shape, and amount. However, to a subject it may not be equal. Though the subject is allowed to adjust the two balls until the subject says they are the same, it is really difficult for the subject to say that one ball has the same amount of play dough as the other one without a fixed reference point. One subject may adjust two balls in his own way a number of times and fail to make them equal in his sense. Without measuring the amount of it, nobody can say that one ball has the same amount of play dough as the other one. There should be a certain external reference which confirms the same amount in two balls. In Piaget's assessment of mass conservation, there is no external criterion. We do not know to what criterion a child is responding. This child may quantify "this amount of clay ball" as volume or weight. For conservation of weight, the test goes as follows:

(I)

Direction	Verbal Instruction
Make two equal balls of play dough (each 3 oz.), saying:	Here are two balls of play dough. One ball is as heavy as the other ball.
Give the balls to the child, and say: (Be sure that the subject picks up the balls and weighs them in his hands.)	Is one ball as heavy as the other, or is one ball heavier than the other?
If the child says they weigh the same, go on to (II).	
If the subject says one weighs more, say:	Let's make them the same. I am taking a little bit away from this one and adding it to that one.

(continued)

	adding it to that one.
Give balls back to subject and ask:	Now, are they the same? Is one ball as heavy as the other?
Continue to adjust the two balls until he says they weigh the same.	

(II)

Make the right ball into a pancake. Flatten the ball until the diameter is 4 inches (use ruler), saying:	Watch, what I am doing. See, I am making one of the balls into a pancake.
When finished, ask: (Do not allow the subject to pick up the ball or pancake.)	Now, is the <u>ball</u> as heavy as the <u>pancake</u>, or is one heavier?
Record, and ask:	Why?
Record.	

In this testing procedures, the subject is allowed to weigh balls in his hands. How much could we trust our hands as a measuring scale? The subject's judgement of the same weight is at best an approximation. This approximation is the basis on which a child is expected to make his criterion response in face of perceptual transformation. This testing process may play a role in favor of Piaget's contention of horizontal dècalage. In assessment of volume conservation, caution should be exercized in the introduction of the jar. Care should be taken to ensure that <u>to the child himself</u> the jars are really the same, that the amount of play dough is the same and the amount of water is the same.

Hypotheses

Major Hypothesis

If Piaget's observation and explanation of a developmentally invariant sequence of conservation of mass, weight, volume are right, then conservers of mass at the age of seven will fail conservation of weight and volume altogether.
The major experimental hypothesis of the present research is that there will be no developmentally invariant sequence of conservation of mass, weight, and volume.

Specific Hypotheses

H.1. Frequency of Piaget's dècalage pattern among the mass conservers from the age of 6:0 to 7:6 will not be statistically significant.

If the logical and developmental priority of identity conservation is true as Elkind (1967) suggested and if Piaget's all or none hypothesis of conservation is wrong, then

H.2. The main effect of format of conservation (identity vs. equivalence) will be significant.

H.3. The interaction effect between format of conservation and the type of task will be significant.

Since the possibility of conservation acceleration is still at issue, it can be expected that conservation can not be simulated within one experimental session. Accordingly, it is expected that;

H.4. Order of presentation of task will not constitute significant variance.

The next chapter will specify the experimental procedures.

Demographic Factors Relating to Conservation

The effects of some of the demographic factors such as intelligence, mental age, sex, socio-economic status, were noted in relation to conservation status.

Elkind (1961 a) reported the multiple correlations among Piaget's tasks (mass conservation using beads, sticks and liquids) and the subtests of the WISC: Information .47, Arithmetic .35, Picture Arrangement .55, Object Assembly .38, Coding .42, Full Scale IQ .43, Verbal IQ .47. In a follow-up study, Elkind (1961 b) found a point biserial correlation of .31 between IQ (Kuhlmann) and conservation of volume with subjects 12 or 13 years of age. Sigel, Roeper & Hooper (1966) did not find conservation ability in four and five year olds who had a Stanford-Binet IQ mean of 149.5. In this latter study, chronological age seemed to be the determining factor.

Work by Feigenbaum (1963) indicated a positive correlation existed between IQ (Stanford-Binet) and the ability to solve correspondence and conservation problems among intellectually superior youngsters, CA four to seven. Correlation of .28 between IQ and conservation of number was found by Dodwell (1961).

Using retardates with MA's five to nine, Mannix (1960) obtained correlations of .61 between Piaget test responses and mental age. Hood (1962) found children with an MA of five or below did not conserve. The relationship between MA and the ability to conserve in six and seven year olds was reported by Goldschmidt (1967) to be significant at the .001 level ($r = .23$ to $.50$).

O'Bryan and MacArthur (1969) found the cognitive structure of reciprocity to be related to intelligence ($r = .68$). McManis (1969) noted that with normal and retardate children performance on intensive and extensive quantities was strongly related to mental age. Achenback (1969) studied the conservation of illusion-distortion identity among normals and retardates and found that the Stanford-Binet mental age seemed to bear a more fundamental relation to conservation attainment than chronological age. The groups of normals and non-organic retardates similar in sex, race, and mental age did not differ significantly in the number of non-conservation responses or in levels of conservation explanations.

Freyberg (1966) also reported that conservation of number scores correlated .52 with a mental age estimate from the Primary Mental Abilities Test.

Sigel and Hooper (1968, p. 519) reviewed the studies concerning the effects of mental age and IQ and summarized that the results employing mental age and IQ are equivocal and that the effect of IQ and mental age varies as a function of the task involved. These writers noted that this may account for the Goodnow and Bethon's (1966) finding that CA was more relevant for conservation tasks and MA for combinatorial problems.

Goldschmidt (1967) found significant sex differences, indicating that boys out-performed girls on every conservation test. Elkind (1962) found similar sex differences on volume tasks. Hooper (1969) also observed sex differences favoring boys.

SES has also been reported to be related to conservation status, favoring children from high SES (Almy et al. 1966).

Since mental ability, sex and SES have been consistantly reported to be related to the conserving ability, these three variables will be maintained homogeneous among the experimental groups.

CHAPTER III

EXPERIMENTAL PROCEDURES

Subjects

Since the major hypothesis of this study is that the horizontal dècalage, in the Piagetian meaning, does not exist, it is wise to limit the age range of subjects to the onset of the concrete operational stage in order to avoid some possible contamination due to age. Three age groups were tested to determine the onset of this stage, kindergarteners, six-year-olds and seven-year-olds. Of 46 boys (Mean age=4:6, SD=2.84) from three kindergartens in Edmonton only three solved conservation of mass (for the procedure, see next section). Accordingly, the data from this group will not be analyzed. Some suggestions from this age group will be mentioned in the next chapter. For the other two age groups, the sample was selected from the population of all boys from grade one and grade two students enrolled in three urban elementary schools of the Edmonton Public School System.

Each subject was given a conservation of mass pretest and asked to describe his father's occupation. Blishen's (1967) scale was used for the approximation of SES.

Teacher-administered IQ scores were obtained, using the Canadian Cognitive Abilities Test, Primary 1 Form 1 for the first graders and Primary 2 Form 1 for the second graders (Thorndike, R.L. et al., 1970).

For 67 of 71 Canadian-born six-year-olds, the above information is completed. 44 of them (65.67%) solved mass conservation, whereas 61 of the 67 (91.05%) seven-year-olds solved mass conservation. Since most of 7-year-old subjects solved mass conservation, there might be some older subjects who are already able to solve conservation of weight. In order to avoid this possibility, subjects above 7 years and 7 months of age were excluded. 80 subjects from the age of 6 to 7½ were randomly divided into 4 groups for experimental treatments, thus constituting 20 subjects in each experimental group. The next section will explain why 4 experimental groups were needed in this study.

Table 1 shows the demographic characteristics of four experimental groups.

Table 1. Demographic characteristics of four experimental groups

Variables		Group 1 (N=20)	Group 2 (N=20)	Group 3 (N=20)	Group 4 (N=20)	Total (N=80)
Age	M	81.95	81.40	81.80	82.05	81.80
	SD	5.73	4.78	4.90	5.20	5.07
IQ	M	113.30	112.95	114.75	113.05	113.51
	SD	14.80	16.67	16.09	15.15	15.41
SES	M	46.39	46.28	46.18	47.24	46.52
	SD	14.18	14.08	19.09	12.39	14.36

(a=b=c=2), it was possible to control subject differences in the evaluation of all of the main effects, leaving all of the interaction effects as mixed effects. Lindquist's Type V mixed design was employed for this purpose (Lindquist, 1956, Pp. 288-292). This Type V design required a^2 (in the present study, $2^2=4$) different groups at random, the subjects in each group taking only a (in the present study, 2) of the possible a^3 ($2^3=8$, in this case) treatment-combinations, no subject taking any treatment in any classification more than once.

Two groups were given first the weight task and then the volume task and the other two groups were given the problems in reverse order. Similarly, two groups were presented with the equivalence format first and then the identity paradigm, and the other two groups were given the paradigms in reverse order. Thus, group 1 was given weight conservation under the equivalence format as its first problem and volume conservation as its second problem; group 2 was given volume conservation under equivalence format as its first problem and weight conservation under the identity paradigm as its second problem. Similar alternating combinations of experimental variables were applied to group 3 and group 4.

The main effects of the three variables in this study were "within" effects, whereas all double interactions were "between" effects, and the triple interaction was "within" effect when a=2 as in the present study.

Conservation Tests

Conservation of Mass

As was mentioned in the previous chapter, there should be an external reference, if not scale, by which subjects can easily agree that one ball has the same amount of plasticine as the other one. One way to do this is to let subjects choose two equal balls among the balls of different size. However, "equalness" of balls does not necessarily mean "the same amount". In this experiment, a scissor type of tool which is commonly used in the kitchen for handling meat-balls was used in making two identical balls. The following test procedures were followed.

> Today I would like to play a game with you using this stuff. Do you know what this is? (allow response) This is play dough. We can make many kinds of shapes out of this play dough. What can you make with this? (allow response, some positive remarks followed; right, or yes.). Now, listen. I am going to make something with this play dough. I will ask some questions. You have to answer the questions and explain why you think so. Could you do that for me?

Verbal Instruction	Direction
Now, watch what I am doing. I am going to make two equal balls out of this play dough.	Make two identical balls.
Here we have two balls (each 3 oz.) of play dough. I think this ball has as much play	

(continued)

dough as the other one. And this one has the same amount of play dough as that one, because I made them equal using this tool. Do you think this ball has the same amount of play dough as that ball?

Reverse the order of pointing the balls.

If S says no, allow him to make them equal until he says they have the same amount.

Now, watch again what I am doing. I am going to make this one ball into a hotdog.

Make 4 inches long sausage, using the prepared modelling shape.

Now, do you think this one (pointing to hotdog) has the same amount of play dough as that one (pointing to ball).

Why? (How come?)

Record and ask.

Conservation of Weight

Yellow play dough and weighing scale were the test materials. For the equivalence form, verbal instruction similar to the above were followed except that 1) subject was allowed to weigh and mark the actual weight of each ball on a white paper attached to a butcher type scale which is a replica of a supermarket scale and can be easily found at a toy store, and then 2) was asked, "what can you say about these two balls?" The confirming response was followed by the question "why?" or "how come?" to make sure that subjects recognize the same weight. 3) After one ball was flattened into a pancake (3 inches in diameter) using prepared modelling shape, the criterion question was asked: where will the red hand of the scale be if you put this pancake on it?

Why (how come)? A second transformation consisted of partitioning one of the balls into five little pieces. For identity, only one ball was used with the same procedures as for the equivalence form (except 2).

Conservation of Volume

Two 6" x 4" x 6" transparent water jars and red play dough were used. For the equivalence form, two water jars were introduced for examination and filled up to 4½ inches high with plain water. The subject was asked to check the water level. Then, as in mass conservation, two equal balls were introduced to the subject. The experimenter transformed one of these balls into a star shape using a prepared modelling shape. The criterion question was asked: "Where will the water level be if we put this star in the water?" Since the water in the jar can be easily coloured when experimenter puts the play dough into the jar, thus perhaps distracting the subject's attention, the test of volume conservation using the clay ball was given without putting the balls into the jar. For the second item, two objects, 4½ inches high and 2 inches in diameter, were used. Each one was put into the water in its upright position. After one of them was rotated by 90°, the criterion question, similar to the above, was asked.

Scoring

Conserving response was the right answer supported by the relevant justifications. The criteria for the relevant justifications were as follows.

Table 3

Criteria for Relevant Justification

Criteria	Example
1) Addition-Subtraction: S stated that nothing had been added or or subtracted.	"You didn't add anything or take anything away."
2) Reversibility: S stated that the transformation could be cancelled and the clay balls would be quantitatively equal.	"If you roll it back into a ball, they will still be made of the same amount."
3) Compensation of Dimensions: S stated that the transformed ball had increased in one dimension and correspondingly decreased in another dimension.	"It's longer but thinner."
4) Reference to previous state.	"It used to be a ball and you change it like this."
5) Nothing changed Quantitatively: S stated that only the shape of the ball changed.	"You just change the shape."
6) Quantitative Equality: S stated directly that the standard and transform were quantitatively equivalent.	"They are still made of the same amount of clay."

Other irrelevant stimulus-bound responses such as "this is round and that is round", or "this is green and that is green too" were not accepted, nor was the "I don't know" statement.

Subject who passed two items altogether under each concept was assigned 2 points. 1 point was given to subjects who solved either one of them. Subject who failed two items altogether was given 0 point.

Statistical Treatment

Since the number of criterion score values is limited to three points, it seemed that X^2 technique with repeated measures suggested by Sutcliff (1957), also by Winer (1962, Pp. 623-627) was relevant. However, the X^2-test has some weak points compared to the F-test. Tsu-Chi Hsu (1969, p. 524) clearly pointed out that 1) X^2-test demands a minimum sample size, 2) it is not easily extended to factorial designs and tests of interactions, 3) it concerns identity of distributions, not just equality of means. Especially for the second reason, the F-test is desirable for this study. Tsu-Chi Hsu (ibid) showed through the technique of computer simulation, that with a three point scale, differences between nominal and estimated true significance levels averaged less than one-half of one percent. Therefore, the F-test can be safely applied to the present study. The Lindquist (ibid) Type V analysis was applied.

Limitations of this study should be mentioned.

First, only male, grade 1 and part of grade 2 subjects were included due to economy of time and manpower.

Second, there were other possible sets of combinations between three experimental variables. The combination used in this study is the only one in which each subject can receive the alternating combination without confounding among experimental variables.

Third, since Piaget's "clinical" approach requires personalized interaction between the experimenter and the subject, some "unknown" experimenter variables might play a role in assessing conservation, even though the present writer was unaware of any bias in experimentation.

CHAPTER IV

RESULTS

The raw data of each individual on weight and volume conservation is given in Table 4 for general reference.

Table 5 shows the summary table of analysis of variance on criterion measures. The major hypothesis of this study was concerned with Piaget's observation of an invariant dècalage pattern. Table 5 shows that the main effect of concept is significant ($p < .01$). This indicates that all mass conservers at this age group are not necessarily weight conservers or volume conservers, which has generally been supportive evidence for Piaget's contention of horizontal dècalage as was shown in Elkind (1961, a, b). However, as was pointed out in chapter 2, this does not necessarily confirm Piaget's contention of the invariant sequence.

Table 6 presents χ^2-test of dècalage patterns. There were only 3 out of 80 mass conservers who failed two items of weight conservation and those of volume altogether, which clearly confirms major hypothesis that the frequency

Table 4

Raw Scores of Each Subject on Criterion Measures

Individual	Group 1		Group 2		Group 3		Group 4	
	I W F	E V S	E V F	I W S	E W F	I V S	I V F	E W S
1	0	1	2	2	2	2	1	2
2	0	0	1	2	2	1	2	2
3	2	2	1	2	2	2	2	2
4	2	2	2	2	2	2	0	1
5	2	2	0	0	2	0	1	2
6	2	1	1	2	2	0	2	2
7	2	1	2	2	2	2	2	2
8	2	2	2	2	2	0	1	2
9	2	2	2	2	2	2	2	2
10	2	2	0	2	2	2	1	0
11	2	2	0	2	2	2	2	2
12	2	1	2	2	2	2	2	2
13	2	0	0	0	2	2	2	2
14	2	0	2	2	2	1	1	2
15	2	0	1	2	2	2	1	2
16	2	2	2	2	2	2	2	2
17	2	2	0	2	2	2	1	0
18	2	0	2	2	2	1	2	2
19	2	2	2	2	2	1	1	0
20	2	1	2	2	2	2	2	2

I: Identity

E: Equivalence

W: Weight Conservation

V: Volume Conservation

F: First

S: Second

0: Non-conservation

1: One item solved

2: Two items solved

Table 5

Summary Table of Type V Analysis of Variance

Source of Variance	Sum of Squares	Degree of Freedom	Mean Square	F ratio
Between Groups	49.094	79		
Format x Concept	.506	1	.506	.80
Format x Sequence	.506	1	.506	.80
Concept x Sequence	.300	1	.300	.47
Error (b)	47.782	76	.628	
Within Subjects	31.500	80		
Format	.300	1	.300	.97
Concept	7.656	1	7.656	24.93
Sequence	.300	1	.300	.97
Format x Concept x Sequence	.876	1	.876	2.85
Error (w)	22.368	76	.307	

F .95 (1, 79) = 3.96 F .99 (1, 79) = 6.96

F .95 (1, 76) = 3.97 F .99 (1, 76) = 6.99

Table 6

χ^2-test for the Dècalage Pattern

		Volume		
		Conserver	Non-conserver	Total
Weight	Conserver	62	11	73
	Non-conserver	4	3	7
	Total	66	14	80

χ^2 obs. = 3.41
χ^2 .95(1) = 3.84 .90 p .95
χ^2 .90(1) = 2.70

* Scale point 1 or 2 is regarded as conserver of each concept.

of Piaget's dècalage pattern among the mass conservers from the age of 6:0 to 7:6 was not statistically significant. It was such an obvious result that even a statistical treatment was not necessary. As for the dècalage between mass and weight conservation, 90% (N=72) of mass conservers solved the two items of weight conservation completely. One subject solved only one item of weight conservation. If we include this subject as conserver of weight, the percentage increases to 91%.

As for the dècalage between mass and volume conservation, 56.25% (N=45) of mass conservers solved completely the two items of volume conservation. If we include 21 subjects who solved one item only, we may say that 82.50% of mass conservers solved volume conservation. If we applied the 75% criterion, which Elkind (1961, b) used, this achievement is above expectation. Further support came from 28 non-conservers of mass. Interestingly, 6 of them solved weight or volume conservation, or both.

One may argue that a one item solver can not be treated as a conserver. However, there is no reason to accept this argument since both were conservation tasks by definition and Piaget's criteria of conservation (right answer + justification) were applied. Furthermore, this is an example of vertical dècalage. Implication of this phenomenon will be discussed in the following chapter.

As was shown in Table 6, X^2-test between weight conservation and volume conservation is not significant at .05 level ($.90 < p < .95$), which means that there is no statistically significant relationship between the two concepts. However, 88% of weight conservers (N=66) solved volume conservation.

Since the main effect of Format and all effects of interactions are not significant (Table 5), Hypotheses 2 and 3 are rejected. At this age group, conservation is achieved in all or non-fashion contrary to Elkind's suggestion (1967).

Accordingly, Piaget's all or none hypothesis of conservation is confirmed.

As was expected, there is no main and interaction effect of counterbalancing variable, which means that there is no systematic carry-over effect among the combinations of format and task.

One may argue that the kinds of justifications made by the subjects may be different depending upon the task involved.

Table 7 shows the kinds of justifications made by the subjects.

Table 7

Frequency of the Kinds of Justification
(N = 80)

Criterion	Mass	Weight		Volume	
		Task 1	Task 2	Task 1	Task 2
1. Addition-Subtraction	20	16	17	7	7
2. Reversibility	13	2	4	1	1
3. Compensation	3	5	3	2	1
4. Reference to previous state	9	9	7	3	4
5. Statement of change in shape	21	17	15	16	18
6. Quantitative Equality	14	24	26	26	25
Sub-Total	80	73	72	55	56
7. Non-conserving response	0	7	8	25	24
Total	80	80	80	80	80

Since Piaget has used the first three categories as the cognitive inferential variables in solving conservation tasks, the above six categories were divided into two parts: first three (1, 2, 3) and the next three (4, 5, 6). Table 8 shows the percentage score of the frequency of justification categories.

Table 8

Percentage Score of the Frequency of Justification Categories

	Mass	Weight		Volume	
		Task 1	Task 2	Task 1	Task 2
First Three	36(45.00)	23(28.75)	24(30.00)	10(12.50)	9(11.25)
Second Three	44(55.00)	50(62.50)	48(60.00)	25(31.25)	47(58.75)
Non-conservation	0(0)	7(8.75)	8(10.00)	25(31.25)	24(30.00)
Total	80(100.0)	80(100.0)	80(100.0)	80(100.0)	80(100.0)

* percentage in parenthesis

The order of decrement in the first categories and increment in the second categories was mass-weight-volume sequence, which assembled Piaget's dècalage pattern. If the second three categories were regarded as non-conserving response, then Piaget's dècalage pattern would be confirmed. But, in fact, as this study shows, children who conserve give a variety of other reasons, which are equally valid. Moreover, it is difficult to see any qualitative differences between them. For example, where is the qualitative difference between "nothing-is-added" (criterion 1) and "they-are-still-the -same-amount" (criterion 6) or "you-just-keep-changing-the-shape" (criterion 5)?

Since the word "same" or "amount" was more frequently used in the introduction of the materials, the subjects might pick up and use this word in their criterion responses in the volume conservations.

Furthermore, it is quite possible that if the experimenter had given the subject one more chance to justify his answer in a different way, then criterion might have been changed into the first three.

Non-analyzed observations deserve some attention.

First, it was rare to observe conservation among 4-year-old 46 kindergarteners under the present procedures. However, their responses during experimentation gave the writer some suggestions.

Episode 1. Some subjects were asking questions to experimenter rather than answering _E_'s question. For example, one subject asked the reason why the water went up when _E_ put the object into the water, when _E_ was asking the criterion question. The experimenter explained but the subject was not satisfied. The subject asked the question again when he was leaving the room. This little episode reminded the experimenter of the discussion made by Isaacs (1930. 292-354). The quality of answer to the why questions asked by children themselves are qualitatively different from the children's answer to the adults' why question. They are seeking information through asking themselves why.

It is unfair to ask the volume conservation question to the child who does not know the behavior of water in general. Once he finds the answer to the question he asked himself with the help of certain instruction, he might solve volume conservation. Isaacs (ibid) pointed out that Piaget generally disregarded the information-seeking behavior of children.

Episode 2. Some subjects' associations were free-wheeling. A subject when asked to make what he would like to make out of one clay ball, made a snow-man. When the criterion question was asked, the subject's answer was, "snow-man is bigger than the ball". What he meant was that the snow-man which was seen through the window at that particular time was bigger than the ordinary ball. Another common response was "my uncle told me so". The children's associations were such diverse that some special experimental procedures should be arranged to control this unpredictable shift of attention. It seemed to the present investigator that the longer the experimental procedures, the more easily distracted the subject's attention is. Standard conservation assessment requires somewhat long time to transform the test material <u>while the subject is watching</u>, during which something is happening to the subjects's imagination.

Isaacs (ibid) criticised Piaget by saying that Piaget's causal thinking questions were assessing the association or fantasy level of children. This possibility also exists in conservation assessment in young children.

Second, for the vivid presentation of the results of the present study, the following examples are given.

Episode 3. An expressive 6½-year-old boy's (IQ = 106) responses.

When the experimenter introduced two equal balls for the assessment of mass conservation and asked whether one ball had the same amount of dough as the other ball, the subject responded:

S: "If I can measure it, (then) I can figure out."

E: "This ball has the same amount of play dough as that because I made them equal by using this tool. Do you agree that this ball has as much as that ball?"

S: "I can say yes, because it looks same."

S: (For mass criterion question) "This (sausage) has more.... It is not easiest thing to say. I don't know.... I said there is same amount. I might think yes. (Why?) Well, you see, you just change that plasticine in different shape.... You know, it is turned in different shape. Well, I say, when I said no, I really meant... you know, I should say yes. You see, both has the same amount just everytime you change the shape into another."

(For volume conservation, equivalence)

<u>S</u>: "Yes, because it has the same amount of dough." (for star shape)

<u>S</u>: "Yes, because it has the same amount." (for angle transformation)

(For weight conservation, identity)

<u>S</u>: "Yes, it used to go to the black mark." (for pancake)

<u>S</u>: "Yes, altogether is the same as ball." (for pieces)

<u>E</u>: "Are you sure?"

<u>S</u>: "Yes, let's check if I am wrong." (He tried to check, using scale.)

This subject vividly supported the writer's arguments in every respect.

Another subject (IQ = 114, age, 7:2) gave following response to the criterion questions.

(For mass conservation)

<u>S</u>: "No... I mean yes, you just crush up. It has still the same amount."

(For volume conservation, equivalence)

<u>S</u>: "It still the same amount of dough there." (for star shape)

<u>S</u>: "It can't change weight." (for angle transformation)

(For weight conservation, identity)

<u>S</u>: "It can't gain weight." (for pancake)

<u>S</u>: "It just same. It has to weigh the same amount and you change the shape." (for partitioning)

CHAPTER V

DISCUSSION

This study addressed itself to the empirical study of Piaget's contention of the invariant developmental dispersion of conservation of mass, weight and volume.

From the examination of a number of Piaget's *post hoc* explanations of this phenomenon the following six points were derived,

1) There is no logical hierarchy among the concepts of mass, weight, and volume. The amount of mass and that of weight refer in the ordinary sense to the same quantity.

2) Conservation approach to concept assessment in general, does not mean the understanding of the definition of a concept as such.

3) Piaget's interpretation of mass conservation is contradictory to his own theory.

4) It seems that Piaget's analysis of the concept of volume does not operate directly on the process of acquisition.

5) Logically, concrete operations do not give any information about the concepts (such as mass, weight, volume).

6) It seems that psychologically reversibility is irrelevant to conservation, since non-conservers understood the reversibility.

In general, Piaget's explanations of the conservation décalage are post hoc; none of them is convincing. Review of the relevant replication studies indicated that the universally invariant sequence was not unequivocally substantiated, using Piaget's original procedures of assessing the three concepts.

Some methodological considerations of ambiguities inherent in Piaget's original experiment pointed to the importance of the following features.

1) The use of words such as "same", "more", or "less" in criterion question was replaced with the relevant concrete perceptual cues such as the movement of hand on a scale or water level in the jar.

2) Introduction of an external point of reference which confirms the same amount in two balls in mass conservation.

3) A weighing scale without numerical values rather than subject's hands was used in weight conservation assessment.

4) Prepared modelling shapes were used to reduce some possible noise factors during a transformation procedure.

The major hypothesis of this study was that the probability of occurrence of Piaget's décalage pattern at the age range from 6 to 7½ years old boys was not statistically significant. Specifically, it was predicted that the mass conservers can solve weight or volume or both.

In general, among 80 6- to 7½-year-old subjects who solved Piaget's mass conservation task, 73 (91%) solved weight conservation whereas 66 (82.50%) solved volume conservation. Only 3 subjects showed Piaget's décalage pattern; that is, conservation of mass and non-conservation of weight and volume at the age of 6 and 7½ years old boys.

Based on this finding, the following points are open to discussion.

First, Piaget (1956) proposed the five criteria of the concept of stage: hierarchization, integration, consolidation, structuring and equilibration (full discussion of these criteria may be found in Wohlwill, 1966 a, b; Pinard & Laurendeau, 1969). For the example of the criterion of consolidation proposed by Piaget to mean that stage n (or period n) is an achievement of the recently acquired behavior and a preparation for the behavior of the following level, Piaget has used his observation of the developmentally invariant sequence of the acquisition of conservation concepts of mass, weight and volume. Since this phenomenon was not substantiated in this study, it may not be a ground for the existence of the concrete stage.

Second, Piaget and Inhelder (1947), and Inhelder (1968) have suggested that this invariant sequence can be used as a natural order scale of intelligence. Since the probability of such sequence among mass, weight and volume conservation was low as was shown in this study, there may not be a sound basis for thinking that the invariant sequence of conservation of mass-weight-volume can be used as a natural order scale of intelligence.

Third, another implication of the main result in this study is that there is a high possibility that conservation of volume can be taught at age 6 or 7. There is no basis for an instructional sequence among these three concetps. The psychological difficulty of volume conservation does not necessarily mean that the volume concept comes later than the other two in instructional sequence. This difficulty is the point where instruction intervenes to keep achievement from being random or natural. Gagné (1968) relevantly concludes that "stages of development are not related to age except in the sense that learning takes time" (p. 188).

Fourth, since this study is an empirical test of Piaget's contention of the décalage, one may ask why the present research showed such contrasting results to the previous researches. This question will be discussed in its broad sense, since chapter 2 of this study examined the possible reasons for the existence of the dècalage. The more important question is: Is it possible in principle to confirm Piaget's contention of the invariant sequence?

If a certain theory contends a certain invariant developmental sequence of concept acquisitions, then it should be based on representative samples of children of different ages from a representative sampling of social, cultural environments. Otherwise, the contention of the invariance sequence would be an overgeneralization, subject to change by further empirical study. Piaget, in general, disregarded this aspect of cultural diversity. Gobar (1968), in his attempt to investigate the French phase of genetic psychology, wrote:

> What the genetic psychology (referring to Piaget) neglects is the "environmental history" of the subject. .... Granting the irrelevance of the historical environment to the study of operations of intelligence, genetic psychology (referring to Piaget) frequently engages in the investigation of the concrete knowledge of the subject. .... As a result of this illicit transition, the concrete knowledge of the subject is sometimes taken as the index of his intelligence.... (Pp. 115-116).

This "environmental history" may give rise to a variety of vertical dècalages. For example, Price-Williams et al. (1969) showed that children from potter families out-performed their age mates on mass conservation tasks because they helped their family making pottery by using clay. Then, what about children who have had some other related experiences such as lifting and cutting meat in butcher shops? The data are not available for weight or volume conservation in this context.

The heterogeneity of objects (test-materials) alone brings about the asynchronisms. For example, Murray (1969) reported that significant numbers of subjects who conserved the mass, weight or volume of the clay ball failed to conserve the same quantity in themselves. As was discussed in chapter 2, some researchers on conservation (e.g. Uzgiris, 1964; Goldschmidt, 1967) suggested that some of non-conservers on one material became conservers on another. If this is the main source of conservation dècalage, then Piaget's demarcation of developmental stages would be content-specific.

Fifth, Piaget has used "conservation item" as the developmental cutting point. Then, the question is: What is a developmental item? If a developmental item means to measure the competence of a child, then we have a very difficult question to solve. What kinds of items are said to measure the competence?

Based on Chomsky's (1965) tradition, Flavell and Wohlwill (1969) have proposed that the specific performance on a specific task depends upon both the subject's cognitive competence and the particular task setting. Cole & Bruner (1971) highlighted this point in a different context. Some researchers have attempted to arrange the special experimental conditions under which conservation in very young children (3 to 5 years of age) could be observed. For example, Mehler and Bever (1967) showed number conservation in subjects below the age of 3. Beilin (1968) and Piaget (1968 b) failed to replicate Mehler and Bever's findings and rejected the application of the term "conservation" to the Mehler and Bever's results. Bever, Mehler and Epstein (1968) confirmed the original Mehler and Bever (1967) findings. Rothenberg and Courtney (1968) reported that an extremely small percentage of young subjects can actually be considered conservers. Calhoun (1971) succeeded in showing that the very young child does have the ability to conserve. Recently Gelman (1972) clearly succeeded in observing number conservation among the very young children with their appeals to addition-subtraction operations by employing a "magic paradigm". Bryant and Trabasso (1971) showed that young children made transitive inferences if precautions were taken to prevent deficits of memory from being confused with inferential deficits.

The above researches really challenge the most important practical import of Piaget's theory of cognitive development, viz., that children under the age of 6 are supposed to be unable to think logically. It may be anticipated that décalages may increase in number as the experimental procedures and test materials are varied. If this is the case, it seems to the present writer that it is not molar enough and molecular enough to account for developmental data.

Sixth, the last point is related to Piaget's principle of genetic epistemology, namely, parallelism between the process made in the logical and rational organization of knowledge and the corresponding formative psychological processes (Piaget, 1970 c, p. 13). The discussion of genetic epistemology proposed by Piaget is beyond this study. This principle, however, may suggest that the evolution of a certain form of thinking in a child follows the sequence of scientific thinking. For example, there are similarities between children under the age of 6 and the presocratic philosophers with respect to the explanations of natural phenomena (Piaget, 1929). However, it is not known whether the similarities exist between the form of thinking of early philosophers and that of our children or between the impoverished state of actual knowledge at that time and the lack of information in our children.

Granting that Piaget's conservation experiments purely measure the form of thinking of children and that there are distinctive stages in the development of the logical thinking as Piaget has observed, Piaget did not study how this logical thinking is used in the specific life situation of a particular child. More specifically, the operations dissociate from the operator of those operations and intelligence is isolated from affectivity in Piaget's theory. If we pay attention to these aspects in his theory, we do not know whether Piaget's stage theory of cognitive development could be proven or not.

It is the opinion of this writer, along with Gelman (1972) that the difficulty level of conservation tasks is dependent upon the number and type of perceptually irrelevant cues actually present when the mechanics of the task are performed; the presence of extra logical factors such as non-verbal assessment, etc., and the amount of time taken to perform the actual task. All these factors will have to be manipulated and controlled in future experimental investigations of the phenomenon of conservation before we can assert with any degree of finality just what factors are, and are not, operating in the performance of conservation. I have demonstrated in this thesis the outcome of one type of experimental procedure, and found the results reported above. Further procedures will have to be designed which will account for the factors mentioned and compared and contrasted with the results of this thesis.

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