# THE PROCESS CURRICULUM

## Cognitive Competence

## Seriation

by Gerard Baruch
and S. Pattabi Raman

with the assistance of:
Daniel C. Jordan
Diane Peifer

ANISA PUBLICATIONS

Box R
Escondido, Calif.
92025

CONTENTS

## DEFINITION

Seriation is a process of arranging, on the basis of ordered differences, concrete objects and events, abstract ideas and constructs for the purpose of organizing one's environment. Specifically, seriation involves differentiating the quantitative variables among an array of elements and integrating these differences to form a graded pattern which can be generalized (extended) to include other elements beyond the original array. For example, in the case of ten sticks of varying length, seriation would first require differentiating the lengths and then arranging the sticks in order of ascending or descending length.

## DESCRIPTION

Piaget defines seriation as "...an additive arrangement of asymmetrical transitive relations" (Inhelder and Piaget, 1964). The term "asymmetric relations" implies differences (differentiation), and the term "transitive" adds the notion of order or connection between those differences. This suggests a sequence or continuum (integration) (Piaget, 1966).

The process of seriation can be performed on abstract ideas as well as concrete objects or events. For example, one may order a series of drawings on the basis of complexity of symmetry. On the other hand, concrete differences include qualities of objects such as weight, volume, area, length, amount, or combinations of these (e.g., density which is equal to wEIght per unit volume). The seriation of events along the temporal dimension requires an adequate grasp of time relations and particularly the concept of speed which is a relation between distance and time.

The ability to seriate abstract or conceptual content emerges as children approach adolescence. An important expression of seriation on an abstract level is the capacity to order one's values on a scale of importance, or to order the events that must take place during a week before a goal can be fulfilled. The remainder of this section will focus on (1) two different forms of seriation (simple vs. multiple) which differ in complexity, (2) the contrast between seriation and its opposite process (classification), and (3) the interface between seriation and correspondence since many studies have dealt with these two processes in conjunction with one another.

### Simple vs. Multiple Seriation

The key distinction between simple and multiple seriation is the number of dimensions along which differences are ordered simultaneously.

Simple seriation entails the ordering of only one difference at a time. For instance, consider a collection of ten blocks, each of which are different in height and weight (see Figure 1). The numbers on the blocks in Figure 1 signify their relative weight. Note the lack of correspondence between relative height and weight.

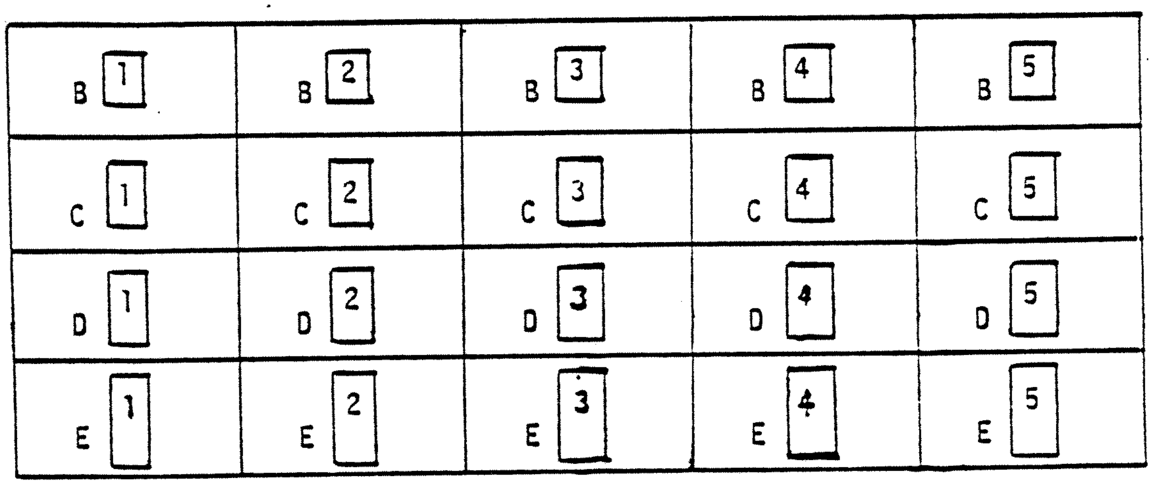


Figure 1

The blocks could be ordered by height either in ascending series, e.g. BCDEFAIGHJ, or in a descending order, e.g. JHGIAFEDCB. They could also be arranged by weight, either IAEHJBFDCG or GCDFBJHEAI. However, in any case the seriation can involve only one dimension at a time. The blocks can be arranged either by weight or by height, but not both simultaneously. It would be inconsistent to begin a series with block B because it is the shortest and then place block F next to it because it is heavier, because this would predicate two differences arranged in a discontinuous series.

Multiple seriation occurs when objects are simultaneously ordered in a series on the basis of two or more differences. In the case of the blocks, a multiple series would require that each degree of height have several gradations of weight associated with it, e.g. there would be five blocks at height B but with weights 1, 2, 3, 4, and 5. Using only four blocks in the series and assuming that each height has five degrees of weight associated with it, the matrix in Figure 2 could be produced.

On the horizontal plane there is a series of increasing weights, while on the vertical plane there is a series of increasing heights. In each direction there is a series of ordered differences. Matrices could be constructed using a decreasing series of heights and weights or a decreasing series of one difference coupled with an increasing series of the other.

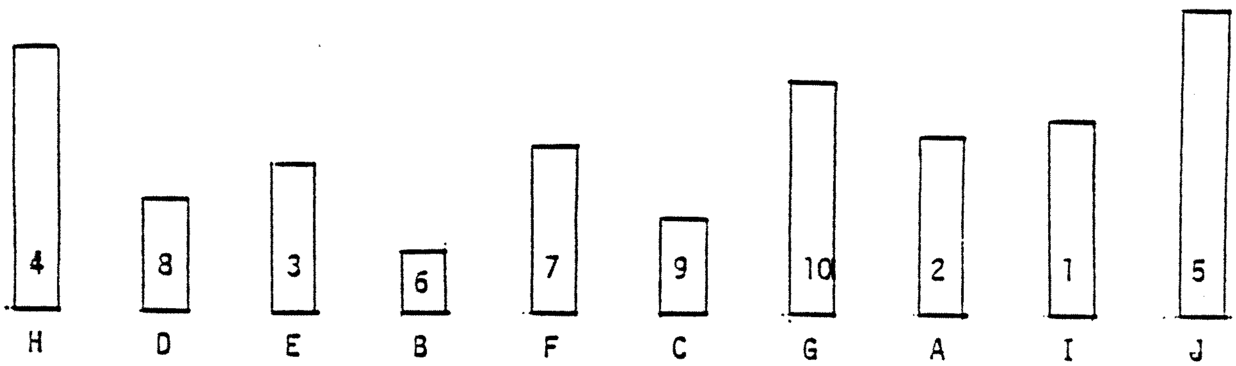


Figure 2

## Seriation vs. Classification

Classification, the process opposite to seriation, consists of the arrangement of objects on the basis of shared qualities or similarities. An example would involve grouping the objects as in Figure 3.

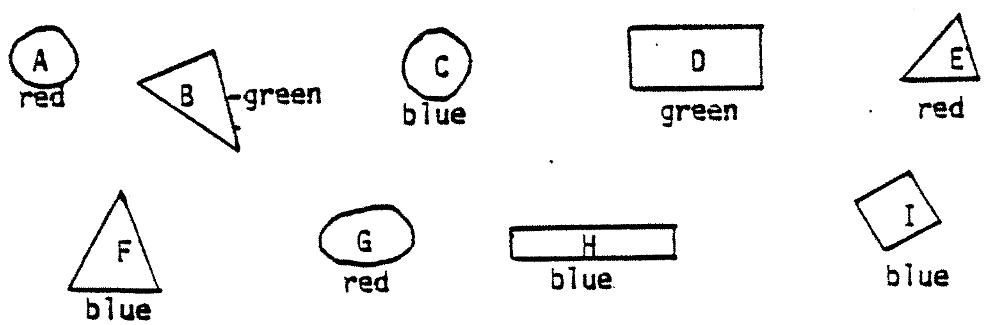


Figure 3

These objects could be grouped by shape. That is, the circles (A, C, G) would constitute one class, the triangles (B, E, F) another, and the rectangles (D, H, I) would be a third class. The objects might be grouped by color, forming classes of red objects (A, E, G), blue objects (C, F, H, I), and green objects (B, D). This grouping of similarities of objects or ideas is not transitive in nature, i.e., there is not the graded order or continuity between the colors or red, blue, or green which is demonstrated with the pattern of decreasing size or height in serial tasks.

## Seriation and Correspondence

Because seriation tasks very often are combined with those involving correspondence, it is important that the meaning of correspondence be clearly understood. Correspondence is the process of pairing objects together on the basis of some relationship which exists between them. The nature of this relationship is dependent upon whether correspondence is combined with a symmetrical or asymmetrical order. If it is combined with a symmetrical order as shown in Figure 4, either of the four elements (dimes or apples) may be first or second in the group. Because the pairs are equivalent, the order is irrelevant. Thus, when a comparison is made as to the corresponding pairs between these two groups of dimes and apples, a child could establish a one-to-one correspondence between any apple and any coin, discovering in the process four pairs of elements. This operation is called cardinal correspondence since the pairing is established irrespective of order (Piaget, 1965).

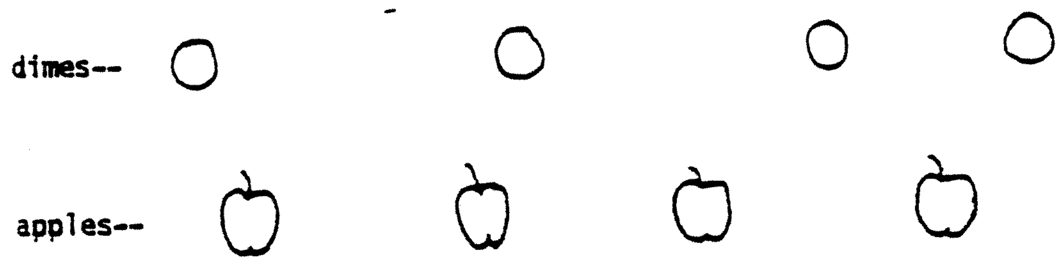


Figure 4

On the other hand, when correspondence is combined with an asymmetrical order of graded differences (seriation), the nature of the pairing is determined by the position of each element in the series. In Piaget's experiments with correspondence a series of ten dolls, each of different heights, and a series of ten sticks, each of different lengths, were used. This task allows children to find possible correspondence between the following series:

(1) The series of dolls arranged by increasing heights paired with the series of sticks arranged by increasing lengths, and

(2) The series of dolls arranged by decreasing heights paired with the series of sticks arranged by decreasing lengths.

If the series of dolls and sticks are arranged according to the figure below then a correspondence can be established between the doll and the stick on the basis of one appearing opposite to the other in the array (see Figue 5). This type of correspondence, which is dependent on the proximity of the doll and its corresponding stick, is known as serial correspondence.

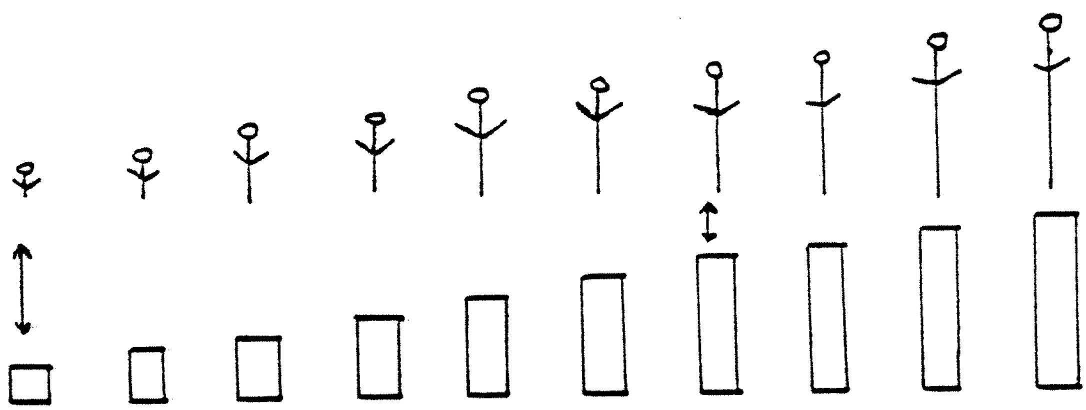

Figure 5

If either series is moved so that the proximity with corresponding members is greatly altered, then correspondence would have to be established on a numerical basis in terms of the relative position shared by each member within its particular series. The similarity between the two series is then generalized to a succession of units (Piaget, 1965). For example, in Figure 6 a correspondence could be established numerically by pairing doll c with stick c, because they are both the third member of a series of five members. Each member has a position in the series, either 1, 2, 3, 4, or 5. This type of correspondence, which Piaget terms ordinal correspondence, is arrived at when "...each element counts as one unit, equivalent in all respects to the others except for its position in the series and every relation of order linking two elements is equivalent to any other" (Piaget, 1965).

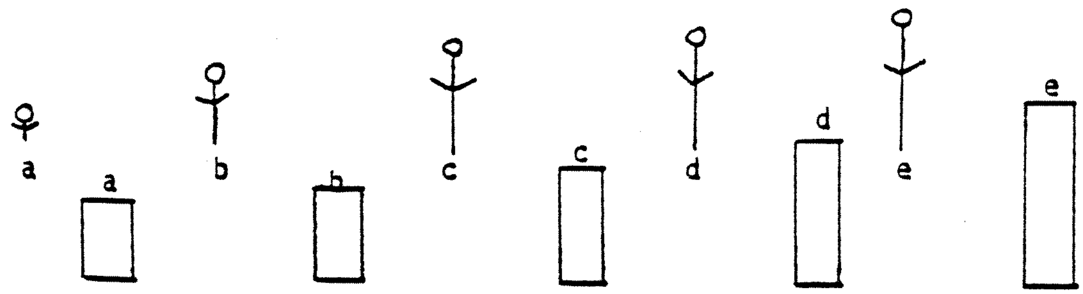


Figure 6

Since serial and ordinal correspondence are the basis for many of the learning experiences designed to foster the development of seriation, three means of organizing such a comparison will be illustrated here while their implications for growth will be cited later in the section on development. The three means of ordering the dolls and sticks are, (1) double seriation, (2) simple seriation and correspondence, and (3) direct ordinal correspondence. Double seriation occurs when the child initially seriates either the dolls or the sticks, then forms another series with the remaining objects, and finally deducts the corresponding pairs from the position of each member in the series. In simple seriation with correspondence the child seriates one of the sets of the objects, either the dolls or sticks, and then finds a correspondence between the members of the unseriated set and the seriated set. Finally, with direct ordinal correspondence there is immediate correspondence without any visible seriation occurring. With this method any seriation takes place mentally and occurrs simultaneously with the process of correspondence itself. This method is sometimes termed direct correspondence (Piaget, 1965).

## THEORETICAL JUSTIFICATION: ANISA

Seriation is critical to the development of learning competence because it gives the child a means of constructing patterns out of differences, thereby reducing the complexity of his environment. Later in adolescence, seriation allows one to arrange abstract constructs and ideas within a system of priorities or order of importance. In fact, the process of thinking in terms of relations (differences) only occurrs when a child is capable of seriating since, as Piaget points out, "...a transitive asymmetrical relation, such as A < B, could not exist as a relation...were it not for the possibility of constructing a whole succession of serial relations such as A < B < C ..." (Piaget, 1966).

Seriation is a prerequisite to the performance of logical and mathematical operations since it is the basis of ordinal correspondence. This, in turn, is functional to the construction of the integer (number) and thus the number system in general (Piaget, 1965). Ordinal correspondence allows the child to understand number sequences or series (e.g. 1, 2, 3 or 10, 11, 12) which give number systems their continuity, thus enabling the child to get from one number to another. For example, if a child wants to find the difference between "9" and "4" and knows the sequence—4, 5, 6, 7, 8, 9—he can mark off five numbers beginning at "4" and move in increasing order until he arrives at "9". Likewise, to get from "9" to "4" he can count five numbers in decreasing order.

In early childhood the genesis of seriation appears when the child first attempts to group objects in global catgories such as big-little, long-short, fat-thin, smooth-rough, loud-quiet, strong-faint odor, or hot-cold. Therefore, global seriation provides the very young child with an initial scheme for differentiating objects in his environment.

An isolated experiment by McManis (1970) indicates that seriation is a basic part of the process of making transitive inferences of inequality (transivity). Referring to Figure 7 transitivity is the inferential step which must be made in deducing the relationship between A and C from the knowledge that A is greater than B and B is greater than C. McManis found

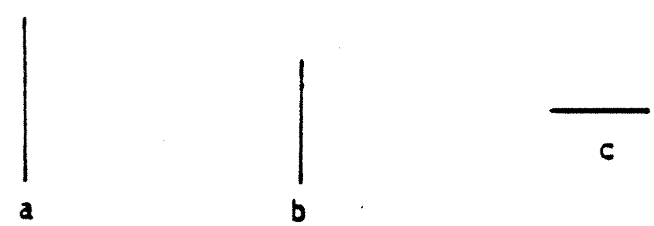


Figure 7

that of a group of 80 normal and 80 retarded children, approximately 60% of each group could do both seriation and transitivity, while 40% suceeded in seriation but failed in transitivity. No one passed the transitivity task while failing to seriate. These results suggest that seriation is neccesary for transitivity, but that transitivty does not have to be mastered for seriation (McManis, 1970). Since both the tasks of seriation and transitivity were done with differences, this data suggests a strong connection between the two processes. However, there is the need for confirming studies as well as similar experiments using other types of differences, such as weight and number, before a final generalization of the effect between seriation and transitivity is determined.

## DEVELOPMENTAL CONSIDERATIONS

Rudimentary forms of the seriation process make their appearance in early infancy while the most advanced and sophisticated expressions are not attained until middle to late adolescence. The present section will trace the development of seriation from the sensori-motor state (0-2 years) through to the stage of concrete operations (7-11 years). A discussion of formal operational seriation (11-13 years) will not be undertaken in this document.

Piaget has identified two major levels in the development of seriation. The first is perceptual seriation which occurs during the sensorimotor and preoperational stages. Sucess at this level is a prerequisite for the second level, operational seriation, which Piaget defines as a mental action which can be reversed (Piaget, 1965).

Sensorimotor seriation (0-2 years). Inhelder and Piaget (1964) point out that, "Seriation exists at the sensorimotor level even if the relevant behavior is unsystematic. A necessary conditions appears to be that the difference between the elements in a series must be fairly sizable so that the child can pick them out just by looking at the material" (Inhelder and Piaget, 1964). Piaget's observations of his daughter's discrimination between the soft and loud noises produced by her rattle led him to postulate that the beginnings of serial order emerged during stage 3 of the sensorimotor period (4-10 months). Later in stage 4, (10-12) he observed further refinements. His daughter would then systematically search for objects that disappeared from her view, even to the point of removing a screen or other obstacle which might be positioned in front of the object. Also, during this stage Laurent began to distinguish an element of quality which occurred when she imitated the sounds of syllables her father repeated to her, words such as "papa" or "papapapa" (Ginsburg and Opper, 1969). Although this might indicate a simple memory task, it does require a discrimination of differences, a factor in seriation.

From these experiments Piaget has found that seriation exists at the sensorimotor level as the process of making gross discriminations between the size of objects, sounds, and any other easily perceived difference. It is the manipulation of objects which begins during this period that allows the child to make perceptually based discriminations later.

Pre-operational seriation (3-7 years). As was indicated earlier, during this stage the child's thinking is very much determined by immediate perceptual and intuitive relations; in such circumstances, the children would superficially imitate more advanced patterns of thought without understanding the underlying internal operation or deep structure. With reference to seriation, activities of this intuitive nature take place in three sub-stages. In the first sub-stage between 3-4 years Piaget found that 53% of his children made no attempt at seriation (Inhelder and Piaget, 1964). In another study, Holowinsky (1970) found that children of 3 or 4 years would not even draw a series given a collection of sticks and an illustration of a series. Instead, they created all types of objects constructed of sticks.

In the next sub-stage, global comparison, children can make drawings of uncoordinated, small series of three and four elements from collections of at least ten objects. These drawings pass through the following phases:

1) Drawings of sticks parallel to one another but whose ends are uneven (figue 8).

2) Drawings where sticks are seriated in collections of two (dichotomous stage - figure 9) and three (trichotomous stage - figure 10), and

3) Drawings where every stick is a different length and there is a correct cluster of three and four sticks seriated properly (figure 11) (Kamii, 1971).

fig. 8

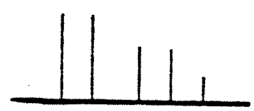

fig. 9

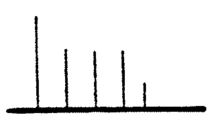

fig. 10

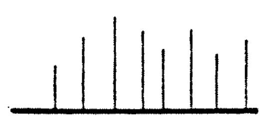

fig. 11

In the last stage, children progress so that more and more sticks are arranged in proper order until the complete series of ten is constructed. This stage is called perpetual seriation and is accomplished through a trial and error method at around 4-6 years (Inhelder and Piaget, 1964).

The above tasks refer to simple seriation alone. However, with the tasks involved in serial correspondence, Piaget found that pre-operational children did not experience increased difficulty. This suggests that the process of correspondence aids in achieving seriation.

Piaget found three developmental levels for both serial and ordinal correspondence of which the first two are pre-operational. In serial correspondence, children of 4-6 years are involved in a "global comparison" stage where there is not yet exact seriation or one-to-one correspondence. In fact, an adult can eventually construct the series for the child by asking many exploratory questions. Once the series of dolls is established the child will attempt to form correspondence between the tallest and the shortest sticks. Some children try to establish corresponding pairs without forming any series. However, children at this stage generally proceed by the method of simple seriation with correspondence, being unable to conceptualize the method of double seriation.

The next stage of serial correspondence is called intuitive progressive seriation and correspondence (5-7 years). At this stage, children succeed in constructing a correct series with a certain amount of trial and error and without the intervention of the experimenter. When children attempt to find a correspondence with a second series, they begin with the method of simple seriation with correspondence, but eventually solve the problem by double seriation.

With ordinal correspondence, children progress through similar stages. In the global comparison stage (4-5 years) children fail to maintain correspondence when one of the two series is modified by either pushing its members closer together, increasing the separation between each member or by reversing the order. In the figure 6, children would pair together stick "c" with doll "b" because of their physical location. Children at this stage do not analyse the positions of the series systematically. Later, when the level of intuitive progressive seriation and correspondence is reached, the child is able to establish correspondence even if there is a large separation between the corresponding elements. In this stage the child achieves the proper pairing either by empirical means or by counting. In the case of the former, the child matches up elements in each series by pointing to each element with his fingers and pairing up the corresponding elements by sight. In the latter method, the child counts through a series until the appropriate number is found. For example, the child is asked to find the match between the stick and the eighth doll in a series, he might count the dolls up up the eighth number (establishing its position) and then count through the row of sticks until the eighth one was reached.

Thus, at this stage the child can establish correspondence on the basis of ordinality through a trial and error method. However, he cannot yet combine his notion of ordinality with that of cardinality. He does not realize that the two series are equivalent in the number of elements regardless of their appearance. Even if he counts up to ten members in each series he still does not grasp that ten dolls and ten sticks are numerically equal. Nevertheless, it is the perceptual discriminations gained at this stage which are internalized and eventually lead toward the level of concrete operations.

Concrete operational seriation (7-11 years). During this stage the child's though achieves a flexibility which was not possible earlier. Operational competence allows the child to manipulate thought on a more abstract level apart from its perceptions. With simple seriation he is able to order a series of ten elements immediately or with little hesitation. The major advancement at this stage is that the child constructs a schema, or pattern such as an increasing slope, according to which he orders the particular elements (see Figure 12).

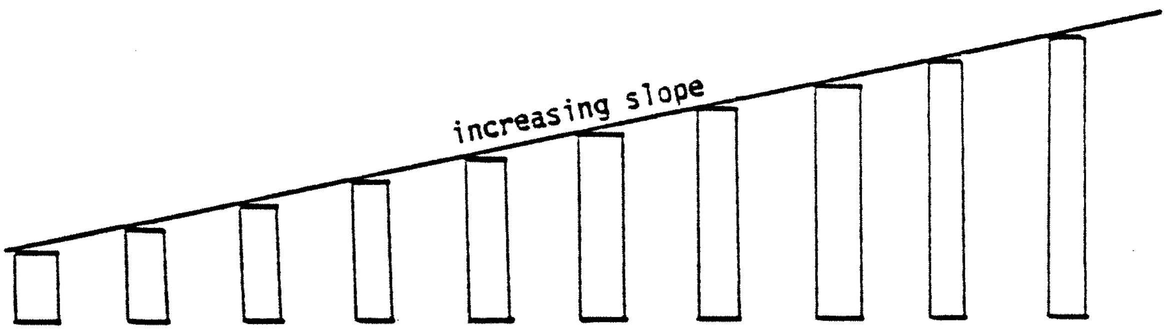


Figure 12

With serial correspondence a new method for finding the corresponding pairs emerges. Not only does the child easily use the methods of double seriation or simple seriation with correspondence, but he now finds a one-to-one correspondence between the dolls and the sticks without previous seriation, since he can now consider the relationship among all the elements. This is referred to as direct correspondence and is characteristic of this developmental level.

Finally, with ordinal correspondence, the child is able to integrate both the ordinal and cardinal aspects of the elements in the series. This integration enables the child to understand that the position of each element in the series constitutes a number and that this number is inseparable from the total series, such that the "nth" element in a series represents both the "nth" position (ordinality) and has the numerical value "n" (cardinality) (Piaget, 1965).

Other Developmental Studies in Seriation

Piaget has conducted a number of experiments which approach the study of seriation from a somewhat different angle. The purpose of these investigations was to ascertain whether a child can anticipate the series before he physically constructs it by manipulating the sticks. The study utilized a variation of the doll - stick problem mentioned earlier. After the experimenter arrayed the dolls, the child was asked to seriate the sticks by making drawings that could be matched to the sticks, first in black and then in color. Afterwards, the child was allowed to seriate the sticks physically. The results show that 89% of the children at four years of age could neither anticipate nor actually perform the physical seriation. By age 6, 73% of the subjects had achieved global seriation, constructing a correct drawing in black and white but not in color. When this same group was allowed to perform the actual seriation, 36% achieved perceptual seriation, 22% operational seriation, while the remainder failed to seriate. By age 7, 80% of the children achieved complete anticipation, that is, they could make a drawing showing the correct seriation complete with the corresponding colors. During the actual seriation, 80% of the children achieved operational seriation on the actual task, while 20% could perceptually seriate, and no one failed to seriate (Piaget, 1964). In subsequent experiments, Piaget succeeded in demonstrating that the drawing of the anticipated seriation is abstracted from the child's own actions with seriable objects rather than being directly abstracted out of his perception (Inhelder and Piaget, 1964).

Holowinsky (1970) investigated the inter-dimensional transferability of seriation and found that pre-school children (3-4 years) were incapable of generalizing what they learned on serial tasks of size to serial tasks of length. However, by age six most children are able to generalize serial patterns from one dimension to another at least 50% of the time. A further point of interest is that children on the average do not achieve mastery on the seriation of weights until two years after they have achieved the same competence in seriation of length (Inhelder and Piaget, 1964).

## PROTOTYPICAL LEARNING EXPERIENCES

General: To differentiate the quantitative variabilities from among an array of elements (actions, objects, or ideas) and integrate these differences to form a graded pattern which can be generalized to other elements sharing differences on the same dimension. Age norms are given to provide a general notion of when the objectives are appropriate. However, it should be remembered that these normative ages are only approximate and will vary among different cultures and classes.

Specific:

Sensorimotor Seriation (0-2 years of age)

1. To distinguish between loud-soft differences using an object from one's environment, e.g., a rattle.

2. To find an object which has perceptually disappeared by removing the barrier which screens the object.

Pre-operational Seriation (3-6 years of age)

3. To identify differences between two objects on the basis of size, length, texture, noise, or temperature.

4. To seriate 3 or 4 objects on the basis of:
   a. size (big-little)
   b. length (long-short)
   c. weight (fat-skinny, heavy-light)
   d. texture (smooth-rough)
   e. noise (loud-quiet)
   f. odor (pungent-odorless)
   g. temperature (hot-cold)
   h. variation in color depth (light-dark)

5. To anticipate serial relationships by drawing a picture of a set of objects in one's environment which can be seriated on the basis of size, e.g., ten sticks, each of decreasing size.

Concrete Operational Seriation (6-10 years of age)

6. To seriate a series of ten objects spontaneously without trial and error and without having to depend on the perceptual configuration of the series, i.e., to arrange a series by figuring the overall pattern which emerges; for instance, a decreasing slope with a series of sticks.

7. To anticipate a series by drawing a series of ten different colored sticks, physically present in front of the child, in proper sequential order using their corresponding colors.

## Guidelines for Writing Learning Experiences

According to Piaget a process such as seriation can be "taught" only by providing those experiences which facilitate a process of accommodation and equilibrium between the child and his environment, according to his present maturational level. It is also important to insure that the child has mastered the processes prerequisite to seriation before engaging them in a complex seriation task.

Prerequisites for Serial Competence

The sub-processes necessary for the development of seriation include: asymmetry, object permanence, and attribute identification. These are defined as follows:

object permanence - the ability to infer the existence of an object even when it is not present in the apparent perceptual field.

attribute identification - the differentiation of specific properties of objects.

asymmetry - the recognition of differences (as opposed to equivalencies) in the relations between objects, e.g., A > B or B < A.

During the sensorimotor period, object permanence, asymmetry, and attribute identification are all important. If children are not convinced of the constancy of an object, then the whole task of seriation is meaningless. If they cannot abstract attributes even unconsciously, they will not be able to recognize differences, and if they do not recognize differences (asymmetry) there would be no need to seriate.

Prototypical Experiences

Experience I:

Objective: To identify the differences between objects on the basis of size.

Level: Pre-Operational—Gross Size Discrimination.

Materials: Generous amounts of play dough, painting supplies, wet sand, tinker toys, or any other construction materials.

Activity: Have child decide what he or she is going to make, but make sure he decides from the beginning whether it will be either large or small or tall or short, etc. After the child constructs the object, the teacher asks the child whether the one he has made is larger or smaller in comparison to other objects in the environment. The objective is to help the child understand that a relation implies a comparison which is dependent on two or more objects (Weikart, et. al., 1971).

Experience 2:

Objective: To seriate 3 or 4 objects on the basis of a difference in height.

Level: Pre-operational—Perceptual Seriation.

Materials: 10 dolls made with paper towel tubes which are identical in diameter but which vary in height over a range of 3 - 7 1/2 inches in 1/2 inch intervals.

Activity: 1. The teacher arranges the dolls in increasing order and asks the child to label which is the father, the mother, and which are the children. Then the teacher randomizes the order of the dolls, selects four dolls and then asks the child to order the dolls with the father on the far left and the smallest baby on the far right.

2. If the child can seriate the above, give him the opportunity to seriate five, six, and eventually all ten dolls in the same fashion (Kamii, 1971).

Experience 3:

Objective: To anticipate serial relationships by constructing a drawing of the series before working with the physical materials.

Level: Pre-operational—Global Anticipation

Materials: Pencil, paper, series of ten sticks ranging from 10.6 - 16 centimeters in height varying in intervals of 0.6 centimeters between sticks.

Activity: Invite the child to draw a picture in which the sticks are properly seriated and then ask him to arrange the sticks according to the picture which he has just drawn.

Evaluation

The above activities can be used as diagnostic techniques because they indicate the developmental level (e.g., pre-operational, of concrete operational, etc.) on which the child is functioning. Such information can be deduced by observing his activity in terms of the amount of time required to complete the task and the predominance of trial and error attempts in his strategy. For instance, if he can order only two or three elements of the whole, he is in State I; if he orders all ten but constantly shifts the sticks around, he is operating on a trial and error basis and is at State II.

Another method of evaluating a child's performance is to note the quality of answers he gives to questions concerning the aim of his activity, and the rationale of his strategy. If the answers show that he is looking at the whole structure in anticipation of a total organizational mechanism, then he is at the level of concrete operations. For instance, if he seriates ten sticks and explains that he is looking at the slope or diagonal which is formed as he places the sticks together then his seriation is operational.

However, caution must be used in evaluating the child's verbal responses since children do not necessarily use words in the same way as adults. Furthermore, there is a stage of growth when a child is inconsistent in his use of words and concepts (Flavell). In many cases, rephrasing and questioning children about concepts using several different lines of questioning will reveal these inconsistencies. It is also important to determine whether a child is merely answering in a way which he feels is expected by the experimenter.

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Simple seriation entails the ordering of only one difference at a time. For instance, consider a collection of ten blocks, each of which are different in height and weight (see Figure 1). The numbers on the blocks in Figure 1 signify their relative weight. Note the lack of correspondence between relative height and weight.

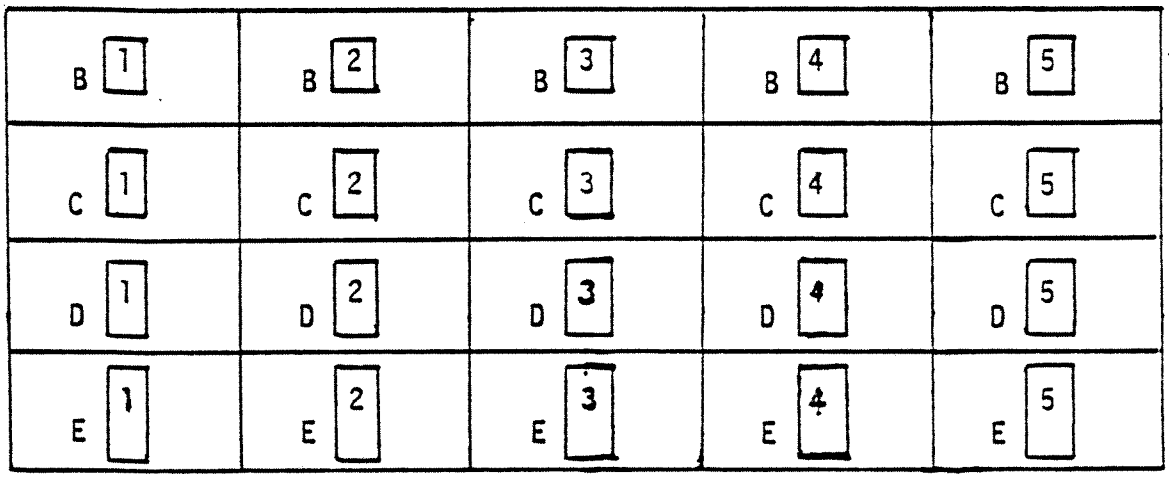


Figure 1

The blocks could be ordered by height either in ascending series, e.g. BCDEFAIGHJ, or in a descending order, e.g. JHGIAFEDCB. They could also be arranged by weight, either IAEHJBFDCG or GCDFBJHEAI. However, in any case the seriation can involve only one dimension at a time. The blocks can be arranged either by weight or by height, but not both simultaneously. It would be inconsistent to begin a series with block B because it is the shortest and then place block F next to it because it is heavier, because this would predicate two differences arranged in a discontinuous series.

Multiple seriation occurs when objects are simultaneously ordered in a series on the basis of two or more differences. In the case of the blocks, a multiple series would require that each degree of height have several gradations of weight associated with it, e.g. there would be five blocks at height B but with weights 1, 2, 3, 4, and 5. Using only four blocks in the series and assuming that each height has five degrees of weight associated with it, the matrix in Figure 2 could be produced.

On the horizontal plane there is a series of increasing weights, while on the vertical plane there is a series of increasing heights. In each direction there is a series of ordered differences. Matrices could be constructed using a decreasing series of heights and weights or a decreasing series of one difference coupled with an increasing series of the other.

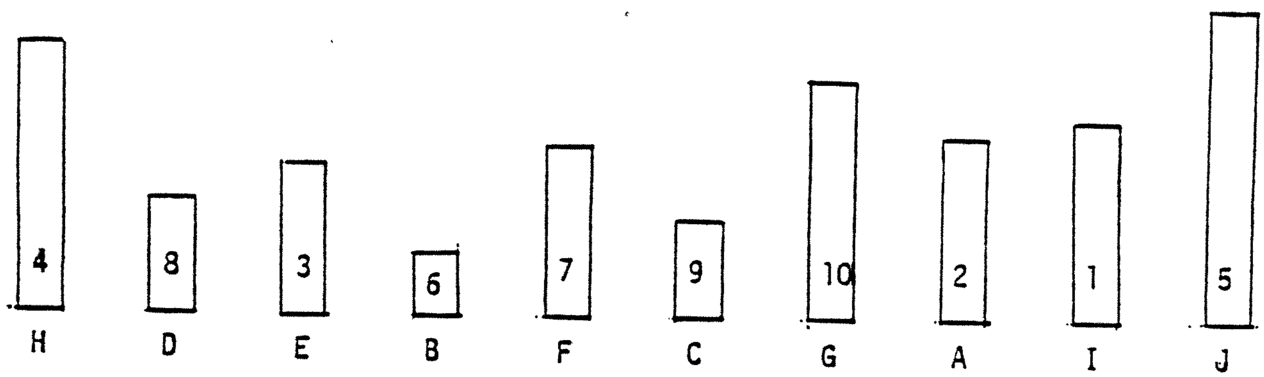


Figure 2

Seriation vs. Classification

Classification, the process opposite to seriation, consists of the arrangement of objects on the basis of shared qualities or similarities. An example would involve grouping the objects as in Figure 3.

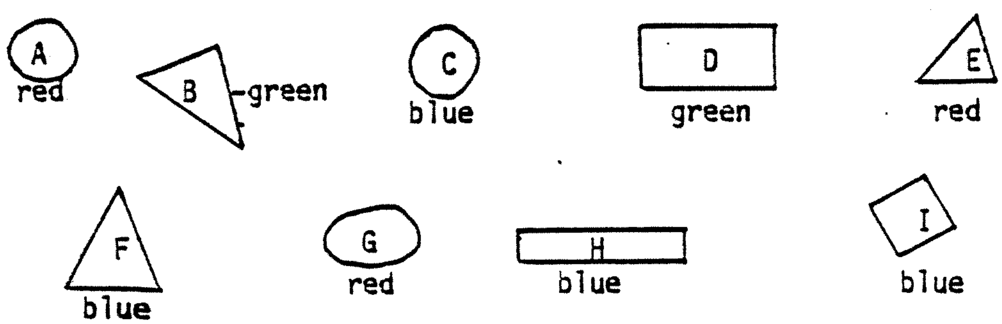


Figure 3

These objects could be grouped by shape. That is, the circles (A, C, G) would constitute one class, the triangles (B, E, F) another, and the rectangles (D, H, I) would be a third class. The objects might be grouped by color, forming classes of red objects (A, E, G), blue objects (C, F, H, I), and green objects (B, D). This grouping of similarities of objects or ideas is not transitive in nature, i.e., there is not the graded order or continuity between the colors or red, blue, or green which is demonstrated with the pattern of decreasing size or height in serial tasks.

Seriation and Correspondence

Because seriation tasks very often are combined with those involving correspondence, it is important that the meaning of correspondence be clearly understood. Correspondence is the process of pairing objects together on the basis of some relationship which exists between them. The nature of this relationship is dependent upon whether correspondence is combined with a symmetrical or asymmetrical order. If it is combined with a symmetrical order as shown in Figure 4, either of the four elements (dimes or apples) may be first or second in the group. Because the pairs are equivalent, the order is irrelevant. Thus, when a comparison is made as to the corresponding pairs between these two groups of dimes and apples, a child could establish a one-to-one correspondence between any apple and any coin, discovering in the process four pairs of elements. This operation is called cardinal correspondence since the pairing is established irrespective of order (Piaget, 1965).

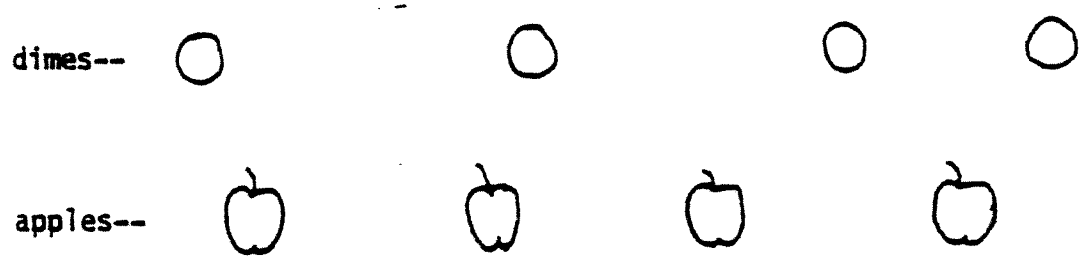


Figure 4

On the other hand, when correspondence is combined with an asymmetrical order of graded differences (seriation), the nature of the pairing is determined by the position of each element in the series. In Piaget's experiments with correspondence a series of ten dolls, each of different heights, and a series of ten sticks, each of different lengths, were used. This task allows children to find possible correspondence between the following series:

(1) The series of dolls arranged by increasing heights paired with the series of sticks arranged by increasing lengths, and

(2) The series of dolls arranged by decreasing heights paired with the series of sticks arranged by decreasing lengths.

If the series of dolls and sticks are arranged according to the figure below then a correspondence can be established between the doll and the stick on the basis of one appearing opposite to the other in the array (see Figue 5). This type of correspondence, which is dependent on the proximity of the doll and its corresponding stick, is known as <u>serial correspondence</u>.

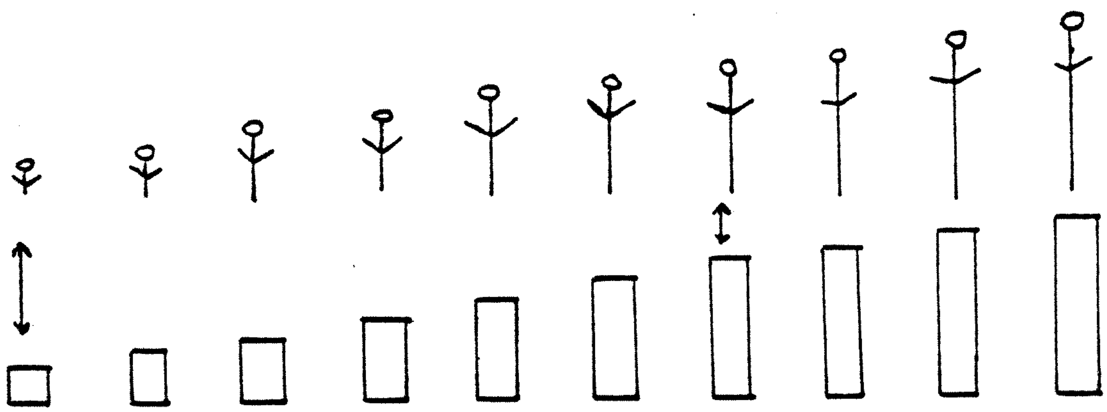

Figure 5

If either series is moved so that the proximity with corresponding members is greatly altered, then correspondence would have to be established on a numerical basis in terms of the relative position shared by each member within its particular series. The similarity between the two series is then generalized to a succession of units (Piaget, 1965). For example, in Figure 6 a correspondence could be established numerically by pairing doll <u>c</u> with stick <u>c</u>, because they are both the third member of a series of five members. Each member has a position in the series, either 1, 2, 3, 4, or 5. This type of correspondence, which Piaget terms <u>ordinal correspondence</u>, is arrived at when "...each element counts as one unit, equivalent in all respects to the others except for its position in the series and every relation of order linking two elements is equivalent to any other" (Piaget, 1965).

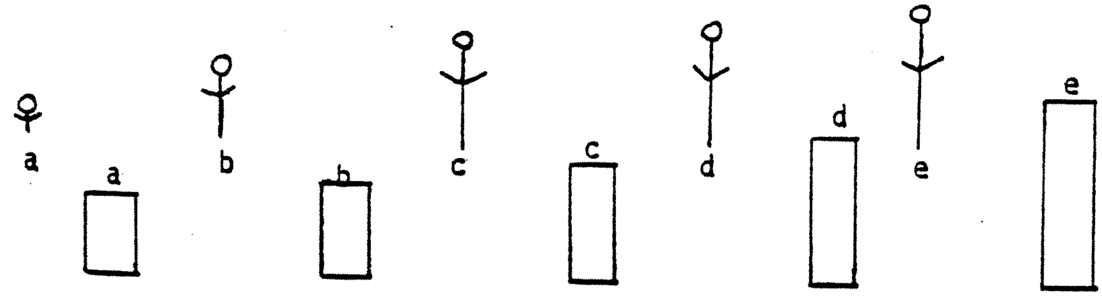


Figure 6

Since serial and ordinal correspondence are the basis for many of the learning experiences designed to foster the development of seriation, three means of organizing such a comparison will be illustrated here while their implications for growth will be cited later in the section on development. The three means of ordering the dolls and sticks are, (1) double seriation, (2) simple seriation and correspondence, and (3) direct ordinal correspondence. Double seriation occurs when the child initially seriates either the dolls or the sticks, then forms another series with the remaining objects, and finally deducts the corresponding pairs from the position of each member in the series. In simple seriation with correspondence the child seriates one of the sets of the objects, either the dolls or sticks, and then finds a correspondence between the members of the unseriated set and the seriated set. Finally, with direct ordinal correspondence there is immediate correspondence without any visible seriation occurring. With this method any seriation takes place mentally and occurrs simultaneously with the process of correspondence itself. This method is sometimes termed direct correspondence (Piaget, 1965).

## THEORETICAL JUSTIFICATION: ANISA

Seriation is critical to the development of learning competence because it gives the child a means of constructing patterns out of differences, thereby reducing the complexity of his environment. Later in adolescence, seriation allows one to arrange abstract constructs and ideas within a system of priorities or order of importance. In fact, the process of thinking in terms of relations (differences) only occurrs when a child is capable of seriating since, as Piaget points out, "...a transitive asymmetrical relation, such as A < B, could not exist as a relation...were it not for the possibility of constructing a whole succession of serial relations such as A < B < C ..." (Piaget, 1966).

Seriation is a prerequisite to the performance of logical and mathematical operations since it is the basis of ordinal correspondence. This, in turn, is functional to the construction of the integer (number) and thus the number system in general (Piaget, 1965). Ordinal correspondence allows the child to understand number sequences or series (e.g. 1, 2, 3 or 10, 11, 12) which give number systems their continuity, thus enabling the child to get from one number to another. For example, if a child wants to find the difference between "9" and "4" and knows the sequence—4, 5, 6, 7, 8, 9—he can mark off five numbers beginning at "4" and move in increasing order until he arrives at "9". Likewise, to get from "9" to "4" he can count five numbers in decreasing order.

In early childhood the genesis of seriation appears when the child first attempts to group objects in global catgories such as big-little, long-short, fat-thin, smooth-rough, loud-quiet, strong-faint odor, or hot-cold. Therefore, global seriation provides the very young child with an initial scheme for differentiating objects in his environment.

An isolated experiment by McManis (1970) indicates that seriation is a basic part of the process of making transitive inferences of inequality (transivity). Referring to Figure 7 transitivity is the inferential step which must be made in deducing the relationship between A and C from the knowledge that A is greater than B and B is greater than C. McManis found

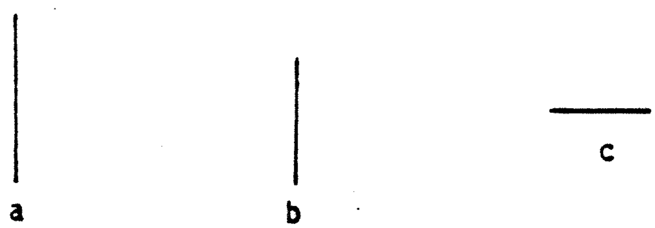


Figure 7

that of a group of 80 normal and 80 retarded children, approximately 60% of each group could do both seriation and transitivity, while 40% suceeded in seriation but failed in transitivity. No one passed the transitivity task while failing to seriate. These results suggest that seriation is neccesary for transitivity, but that transitivty does not have to be mastered for seriation (McManis, 1970). Since both the tasks of seriation and transitivity were done with differences, this data suggests a strong during this stage the child's thinking is very much determined by immediate perceptual and intuitive relations; in such circumstances, the children would superficially imitate more advanced patterns of thought without understanding the underlying internal operation or deep structure. With reference to seriation, activities of this intuitive nature take place in three sub-stages. In the first sub-stage between 3-4 years Piaget found that 53% of his children made no attempt at seriation (Inhelder and Piaget, 1964). In another study, Holowinsky (1970) found that children of 3 or 4 years would not even draw a series given a collection of sticks and an illustration of a series. Instead, they created all types of objects constructed of sticks.

In the next sub-stage, global comparison, children can make drawings of uncoordinated, small series of three and four elements from collections of at least ten objects. These drawings pass through the following phases:

1) Drawings of sticks parallel to one another but whose ends are uneven (figue 8).

2) Drawings where sticks are seriated in collections of two (dichotomous stage - figure 9) and three (trichotomous stage - figure 10), and

3) Drawings where every stick is a different length and there is a correct cluster of three and four sticks seriated properly (figure 11) (Kamii, 1971).

fig. 8

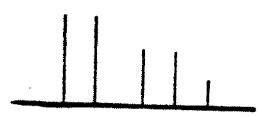

fig. 9

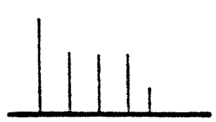

fig. 10

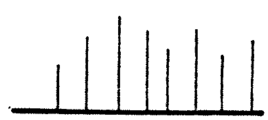

fig. 11

In the last stage, children progress so that more and more sticks are arranged in proper order until the complete series of ten is constructed. This stage is called perpetual seriation and is accomplished through a basis of ordinality through a trial and error method. However, he cannot yet combine his notion of ordinality with that of cardinality. He does not realize that the two series are equivalent in the number of elements regardless of their appearance. Even if he counts up to ten members in each series he still does not grasp that ten dolls and ten sticks are numerically equal. Nevertheless, it is the perceptual discriminations gained at this stage which are internalized and eventually lead toward the level of concrete operations.

Concrete operational seriation (7-11 years). During this stage the child's though achieves a flexibility which was not possible earlier. Operational competence allows the child to manipulate thought on a more abstract level apart from its perceptions. With simple seriation he is able to order a series of ten elements immediately or with little hesitation. The major advancement at this stage is that the child constructs a schema, or pattern such as an increasing slope, according to which he orders the particular elements (see Figure 12).

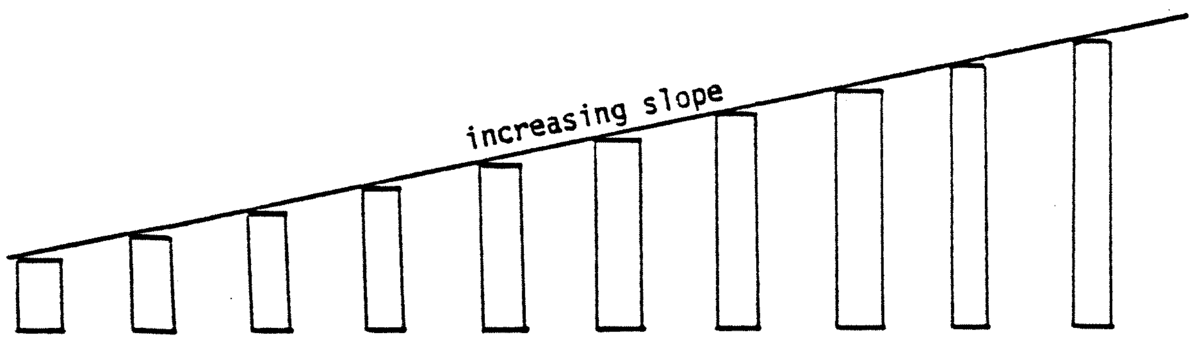


Figure 12

With serial correspondence a new method for finding the corresponding pairs emerges. Not only does the child easily use the methods of double seriation or simple seriation with correspondence, but he now finds a one-to-one correspondence between the dolls and the sticks without previous seriation, since he can now consider the relationship among all the elements. This is referred to as direct correspondence and is characteristic of this developmental level.

Finally, with ordinal correspondence, the child is able to integrate both the ordinal and cardinal aspects of the elements in the series. This integration enables the child to understand that the position of each element in the series constitutes a number and that this number is inseparable from the total series, such that the "nth" element in a series

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