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ABSTRACT

The relationships among the perception, representation, and construction of series are examined within a model of the acquisition of seriation abilities. The model is then related to two experiments with three-, four- and five-year-olds. The key feature of the model is the delineation of parallels among developmental changes in three arenas: changes in the information that can be perceptually extracted from a series, changes in the information that can be represented and used without perceptual support, and changes in algorithms or procedures for constructing series. To examine the kind of information that can be perceptually extracted from series, a three-choice discrimination learning task was employed. Three sets of stimuli were employed: three nonseries, two nonseries and one series, one ascending and one descending series and one nonseries. Performance improved with age. The two series stimulus set was the hardest and revealed confusion between the two series. To examine production skills, subjects were asked to perform several tasks involving selecting items, constructing small and large series, and inserting items into a series. Performance improved with age. Random construction procedures preceded systematic construction, which preceded insertion skills. These data were used to support a model of the development of seriation in which perceptual abilities precede or are coincident with representation skills which preceded or are coincident with construction skills. In addition, a parallel in the course of development across the three arenas was proposed. (Author/MS)

# The Development of Skills Underlying Perception, Representation, and Construction of Series

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The Development of Skills Underlying

Perception, Representation, and Construction of Series

One of the insights developmental psychologists have gained from Piaget is that children's understanding of concepts differ from that of adults; the difference being predictable from the structure of the concept. One concept which has received considerable attention is children's understanding of series; like the one pictured on the left in the top row (Figure 1). Series originally were investigated because they were thought to be important in the development of number concepts, and although this is now disputed by some, series have become of interest in their own right.

In this paper I will be considering how 3, 4, and 5 year-old-children perceive, represent and construct series. Do young children perceive series in the same way as adults; such that they can easily discriminate the series on the left in the top row from the non-series in the center and on the right of the top row? Do they represent series in such a way that they know that the third element in this series is larger than the second and smaller than the fourth; that is, do they know that the elements surrounding any element in a series will be greater in some dimension on one side and less on the other? Finally, do they have systematic strategies for constructing series; like choosing the smallest element, then choosing the smallest of the remaining elements and putting it to the right of the first, and continuing to choose the smallest element of those remaining and placing them on the right, or do children just use trial and error construction strategies?

I will present the results of two experiments testing aspects of a model which relates the skills for perception, representation, and construction of series. Then the model will be related to these two experiments and used to highlight gaps in the seriation literature. The key feature of the model is the delineation of developmental parallels in three arenas: changes in the information that can be perceptually extracted from a series, changes in the information that can be represented and used without perceptual support (that is, the knowledge of series), and changes in algorithms or procedures for constructing series.

To examine the kind of information that can be perceptually extracted from a series, a three-choice discrimination learning task was employed. The stimuli consisted of pictures of series and non-series of black rectangles. Each of three learning conditions in the experiment contained three such pictures. The single series condition contained pictures of one series and two non-series (top row of Figure 1). The double series condition contained pictures of two series, one increasing and one decreasing from left to right, and on non-series (middle row of Figure 1). The non-series condition contained pictures of three different non-series (bottom row of Figure 1). The children in the experiment experienced only one of the three learning conditions. For all three learning conditions, each picture served once as the to be learned stimulus while the other two pictures served as distractor stimuli. The children's task was to select the to be learned stimulus rather tha either of the two distractor stimuli on each presentation trial. This procedure continued until the children reached a criterion of seven correct out of the last ten presentation trials, or until thirty presentation trials. Thus, one dependent measure was the number of trials to reach criterion for each stimulus picture with the minimum possible being seven and the maximum possible being thrity. A second dependent measure involved the distractor stimulus chosen on error trials.

The reasoning underlying the three learning conditions employed is as follows: First consider a child who can only discriminate a series from a non-series and is incapable of discriminating series on other features (for example, the direction of increase). In the single series condition this child would not confuse the single series with the two non-series, thus the one series would be learned to criterion in fewer trials than the two non-series, and the two non-series would be confused with each other. In the double series condition this child would now not confuse the one non-series with the two series, thus the one non-series would be learned to criterion in fewer trials than the two series, and the two series would be confused with each other.

Consider a second child who cannot only discriminate series from non-series, but can discriminate series on other features, such as the direction of increase. In the single series condition, this second child will perform as well as the first. In the double series condition, this second child is less likely to confuse the two series with each other than the first child.

In the non-series condition, the control, the number of trials required to learn each of the three non-series to criterion would be expected to decrease with increasing learning skill, but performance should not depend on series-specific skills. Thus, this condition provides a base-line measure.

An analysis of variance indicated that trials to criterion decreased with increasing age for the 3, 4, and 5-year-olds participating in the experiment. Additionally, the single series condition was easier than the double series condition. Planned comparisons revealed that 3, 4, and 5-year-olds were similar in their ability in the single series condition to discriminate between a series and a non-series. However, 3-year-olds had considerably greater difficulty in the double series condition in discriminating between ascending and descending series than did either the 4 or 5-year-olds. Although 4 and 5-year-olds can discriminate between ascending and descending series it is a less salient dimension for them than the series/non-series dimension.

The pattern of errors indicated that the two non-series in the single series conditions were confused with each other by the 4 and 5-year-olds, while the 3-year-olds did not show this pattern. And, that the two series in the double series conditions were more often confused with each other by all three age groups. Lastly, two stimuli, whether series or non-series, which both contained the smallest rectangle at either end were frequently confused with each other, and two stimuli which both contained the smallest rectangle in the interior were frequently confused with each other. Both of these confusions were shown more by the three year olds. These patterns reveal the use of the the following strategy, particularly by the young children: The little rectangle is either at an end or is not at an end. Of course, this strategy would not allow the child to reliably discriminate between series and non-series, and appears to be a precursor of the series/non-series discrimination.

In summary, the first experiment indicates that 3, 4, and 5-year-olds can perceptually discriminate series from non-series, and that 4 and 5-year-olds can discriminate series on the basis of direction of increase, but less reliably than the series/non-series discrimination. Further, it shows that a strategy children employ when they are not making use of the full series information is simply to determine if a particularly salient element in the series is at either end of the series or not at either end.

In the second experiment, several tasks were employed to assess skills for constructing series. The stimuli consisted of four sets of pictures with each set containing eight individual pictures varying on some ordered dimension (Figure 2). For example, one set of eight pictures were drawings of circles of various diameters. The children in the experiment experienced 3 of the 4 stimulus material sets. The children were presented with 5 tasks for each of their stimulus material sets. The 5 tasks were presented as follows: The first was a paired comparison in which the children were to choose one picture from a set of seven that was most like a standard. The second task was to construct a large series with seven pictures. If a child failed this second task, the third task was then presented. It was identical to the second task except a model of the final series was available for inspection by the children. If a child failed this third task, the fourth task was then presented. It was to construct a small series with 4 pictures. Upon the successful construction of a 7 or a 4 element series, the fifth task was presented. It was to insert an additional interior element into the already constructed series.

Performance on all 5 tasks increased with age for the 3, 4, and 5-year-olds participating in the experiment. The tasks ordered in difficulty in the following way: the paired comparison task was easiest, the small series construction task was more difficult, the insertion task was next most difficult, and the model and no model large series construction tasks were most difficult and of about equal difficulty. Three-year-old children were only successful at the paired comparison task. Four-year-old children demonstrated the additional abilities of constructing a small series and to a lesser extent inserting an interior element into an already constructed series. Five-year-olds demonstrated the additional abilities of inserting an interior item into an already constructed series and to a lesser extent to construct large series. Children who succeeded on small, but not large series used a more random construction process involving placement of items and perceptual checking of the result. Children who succeeded on the larger series used an algorithm of choosing the smallest element, then the smallest of those remaining, and so on; or choosing the largest element, then the largest of those remaining, and so on. Many of these children made occasional errors which were apparently the result of not systematically searching the set of remaining items.

Our model of the development of seriation skills proposes that perceptual skills are prerequisite for both representation and construction skills (that is, features of a series must be preceptually discriminated before, or coincident with their use in representations of series). Comparisons across the two experiments reported support this view. Further, representation skills are prerequisite for construction skills. The lack of difference between the model and no model construction tasks supports this view. Further, the natural emergence of the strategy which led to success for the seven-item series suggests knowledge of the asymetrical transitive relation involved in a series.

In conclusion, the course of development in the perception, representation, and construction of series is proposed to reflect use of information in the following sequence: First, paired comparisons between items; second, differences between series and non-series; third, direction of series; fourth, magnitude of differences between adjacent items in a series; and finally, magnitude of increments in a series. We have presented evidence in both the perceptual and construction arenas for the first three items in the sequence above. The last two are the subject of current research and are important because they relate directly to the issues of ordinal versus interval scales, units, and scale factors in number development.

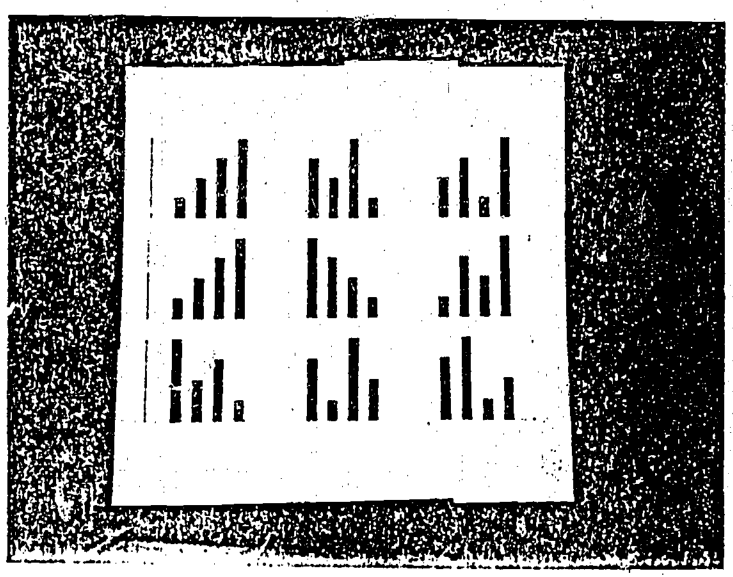

Figure 1

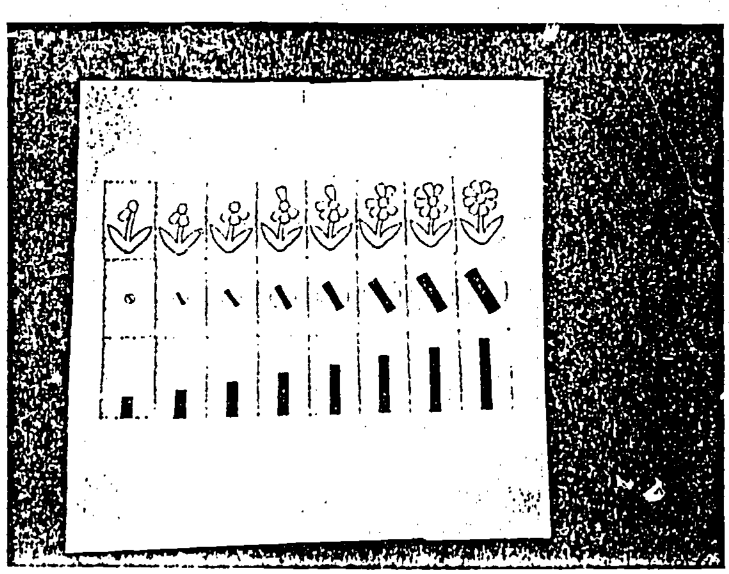

Figure 2