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ABSTRACT

The purpose of this study was to investigate the development of organizational processes for both verbal and spatial stimulus materials within an information processing framework. Children in grades 2 and 4 and adults were tested for their ability to report letter strings reflecting various orders of approximation to English and various dot patterns reflecting different types of symmetry. Patterns were presented tachistoscopically at four exposure durations (50, 100, 150 and 200 msec), followed by a patterned mask. Results indicated that subjects in all three age groups showed greater ability to extract information from the iconic store if materials were structured. Moreover, subjects increased in the ability to extract information from verbal materials as they grew older. No age-related change in extraction efficiency was noted for the spatial materials when age-related differences in absolute short-term memory capacity were controlled. (Author/ED)

The Organization of Verbal and Spatial Materials Presented Tachistoscopically: A Developmental Study

by

Sally L. Boswell

Paper presented at the Biennial Meeting of the Society for Research in Child Development, April, 1975, Denver, Colorado [1]

Abstract

The purpose of this study was to investigate the development of organizational processes for both verbal and spatial stimulus materials within an information processing framework. Children in the second and fourth grade and adults were tested for their ability to report letter strings reflecting various orders of approximation to English (zero-order, second-order and fourth-order) and dot patterns reflecting different types of symmetry (asymmetry, vertical symmetry and double symmetry. Patterns were presented tachistoscopically at four exposure durations (50, 100, 150 and 200 msec), followed by a patterned mask. The results indicated that subjects in all three age groups showed greater ability to extract information from the iconic store if materials were structured. Moreover, subjects increased in this ability with age for the verbal materials. No age-related change in extraction efficiency was noted for the spatial materials. The results also indicated that once age-related differences in absolute short-term memory capacity were controlled, subjects showed increasing efficiency in organizing verbal materials with age, whereas their ability to organize spatial materials remained essentially invariant with development.

During the past several decades, the information processing approach to perception and cognition has provided a useful model with which to investigate development. This approach is useful for two reasons. First, it provides a model of processing in which stimulus input is viewed as passing through a number of interrelated stages where various transformations take place. Second, investigators have devised a number of reliable experimental techniques with which to delineate the properties associated with each of the stages. Thus, by comparing the performances of subjects in several age groups using these procedures we can determine the developmental parameters associated with the various stages.

Several aspects of this system are characterized as having processing limitations. For example, when a display of items is presented tachistoscopically, an iconic image remains for about 200 msec, which is often too brief a period for subjects to scan or extract all the material from the display. A second limitation is in short-term memory, where it is a classic finding that adults recall approximately four to six items. Children, of course, have even more limited short-term memory capacities. In order to overcome these limitations subjects must organize materials. One method of accomplishing this is for subjects to group two or more elements into single processing units.

The purpose of this study was to investigate the development of organizational processes for both verbal and spatial stimulus materials. The method typically used to investigate organizational processes for materials contained in brief visual displays is to present subjects with both structured and unstructured stimulus materials. It is assumed that if subjects report more items from the structured materials than from the unstructured materials, the difference must be explained in terms of organization. In the present study the verbal materials were comprised of three orders of approximation to English (see Fig. 1). Approximations to English reflect the frequential and sequential probability distributions of letters in normal English text. Each display contained 16 letters in two rows of eight letters each. The spatial materials were comprised of three types of symmetry: asymmetry, vertical symmetry, and double symmetry (see Fig. 2). Subjects were asked to report as many letters as possible from the verbal displays and to reproduce the dot patterns as accurately as possible on blank grids.

The few developmental studies which have presented structured and unstructured materials in tachistoscopic displays have found that the beneficial effect of structure increases with age. That is, both children and adults report more items from the structured material; however, the adults benefit more than the children. It is impossible to determine the source of this interaction on the basis of these studies. One possibility is that children are not as efficient as adults in scanning or extracting information from the arrays. If so, children would show slower scanning rates than adults, and scanning

differences would depend on the structure of the materials presented. A second possibility is that children are not as efficient as adults in chunking or grouping material in short-term memory. Adults, for example, may combine three or four elements into a group, whereas children, particularly in initial stages of reading skill development, may only group two letters into a processing unit. Either or both of these components would contribute to the age-related effects shown in previous research.

In the present study the method used to investigate these two components was to present materials at four exposure durations (50, 100, 150 and 200 msec) followed by a mask, comprised of densely spaced letter fragments, dots and lines. Scanning or extraction was investigated by examining performances at the brief exposures, when short-term memory capacity was not attained. Organization of information in short-term memory was examined by comparing subjects on their performances for materials at the longer durations, when scanning more items presumably no longer added to the level of performance. Finally, by looking at performances across a range of exposure durations, age-related differences in performance for the complete organizational process were investigated. There were three groups of subjects: second graders, fourth graders and adults. All subjects were presented with both verbal and spatial materials.

First, the results from the entire range of exposure durations will be considered for each age and material separately. Second, the results will be briefly discussed in terms of the components of processing.

The verbal materials are presented in Fig. 3. The second grade subjects showed increasing reporting ability with exposure duration and structure. Interestingly, at no exposure could these subjects differentiate between second- and fourth-order material. Also, not until 100 msec did the second graders differentiate the structured material from the unstructured material. The fourth grade subjects showed a higher level of performance than the second grade subjects and also showed a facilitative effect of structure and exposure duration. This facilitation was greater than for the second grade subjects. The adult subjects showed both a higher level of performance and a greater facilitative effect of structure and exposure duration than the children. For the verbal materials, then, subjects increased in performance with age, and age interacted significantly with structure and exposure duration.

For the spatial materials (see Fig. 4) the second grade subjects generally showed higher levels of performance than they did on the verbal materials. They showed a facilitative effect of symmetry at all exposure durations with highest performance for the double patterns, followed by the vertical and asymmetrical patterns. The fourth grade subjects showed even higher performance levels than the second grade subjects and readily differentiated between the symmetry types. The similarity between the performance of the adults and that of the fourth graders was striking for the spatial materials. Because of obvious ceiling effects for the double symmetry patterns, these data were removed from most analyses of variance.

For both verbal and spatial materials the expected age by level of structure interaction was obtained. How can we account for this finding in terms of the processing components discussed earlier? To determine if there were age-related differences in scanning rates, performances for the subjects in each age group were analyzed using the data from the 50 and 100 msec trials only. The results for the spatial materials are shown in Fig. 5. Note that although the adults showed higher performances than the children, there were no differences between the age groups in the rate at which material was extracted. Note also that subjects extracted symmetrical materials more efficiently than asymmetrical materials, and again there were no age-related differences in the rate of extraction.

For the verbal materials, however, there was quite a different pattern of results (see Fig. 6). The adults showed faster scanning rates than the children for both the structured and unstructured material. All age groups showed faster scanning rates for the structured materials than the unstructured materials, and this difference was greater for the adults than the children.

The second component which was investigated was organization in short-term memory. The assumption was made that performance at the 200 msec duration reflected short-term memory capacity for the different materials. That is, even if more items were scanned, the level of performance would not be affected because of capacity limitations in short-term memory. When the performances of the adults and the children were compared for the fourth-order and zero-order material at 200 msec there was a significant interaction which reflected that the beneficial effect of structure increased with age.

This interaction was further examined by controlling for age-related differences in absolute short-term memory capacity. This was accomplished by using the performance for the random unstructured materials as a baseline for each age group and comparing this baseline with the performance shown for the structured materials. To give a hypothetical example: assume that the second grade subjects reported two items from the unstructured material and four items from the structured material. This would indicate that these subjects organized the four items into two groups containing two elements each. Now, assume that the adults recalled three letters from the random materials. If they also organized the structured materials into groups of two elements, then we would predict that they would recall six elements from the structured material. If they reported significantly more items than the predicted six, then we would conclude that the adults were organizing the structured material into larger groups of elements than the children were. When this analysis was actually carried out on the data from the present study, it was found that the second grade subjects organized verbal information less efficiently than the adults, while the fourth grade subjects did not differ from the adults. For the spatial materials, however, there were no differences between the age groups in the ability to organize these materials.

In sum, the present study showed developmental changes in both scanning verbal materials and organizing verbal materials in short-term memory. However, we found no indication of age-related effects for these components for the spatial materials. One possible explanation is that the detection of symmetry in the environment is a fundamental processing capacity which evolves early in development. Thus the components associated with the organization of spatial material remain essentially invariant with development, aside from changes in absolute memory capacity. The organization of verbal materials, however, represents a highly complex process and necessarily depends on specific environmental experience. We know then, that when a child learns to read, he brings a highly developed organizational system to bear on the task.

GWVGERPI

JFZAECZW

Zero-order

ORERSULD

ABUDULLO

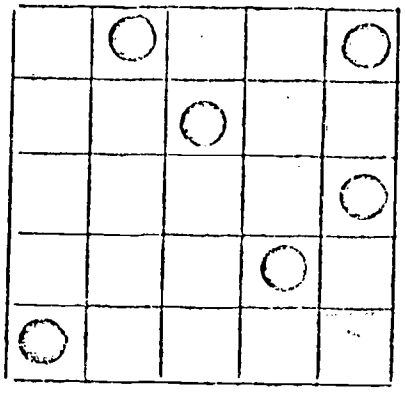
Second-order

PLODDENT

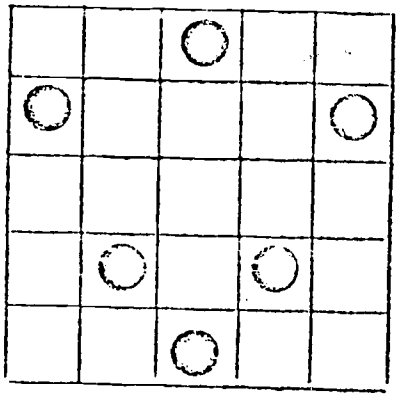
FOREDIUM

Fourth-order

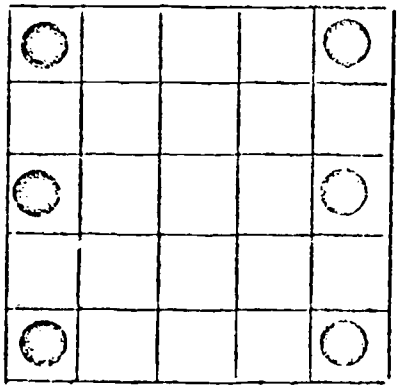
Fig. 1. Examples of approximations to English.



Asymmetrical



Vertical



Double

Fig. 2. Examples of dot patterns.

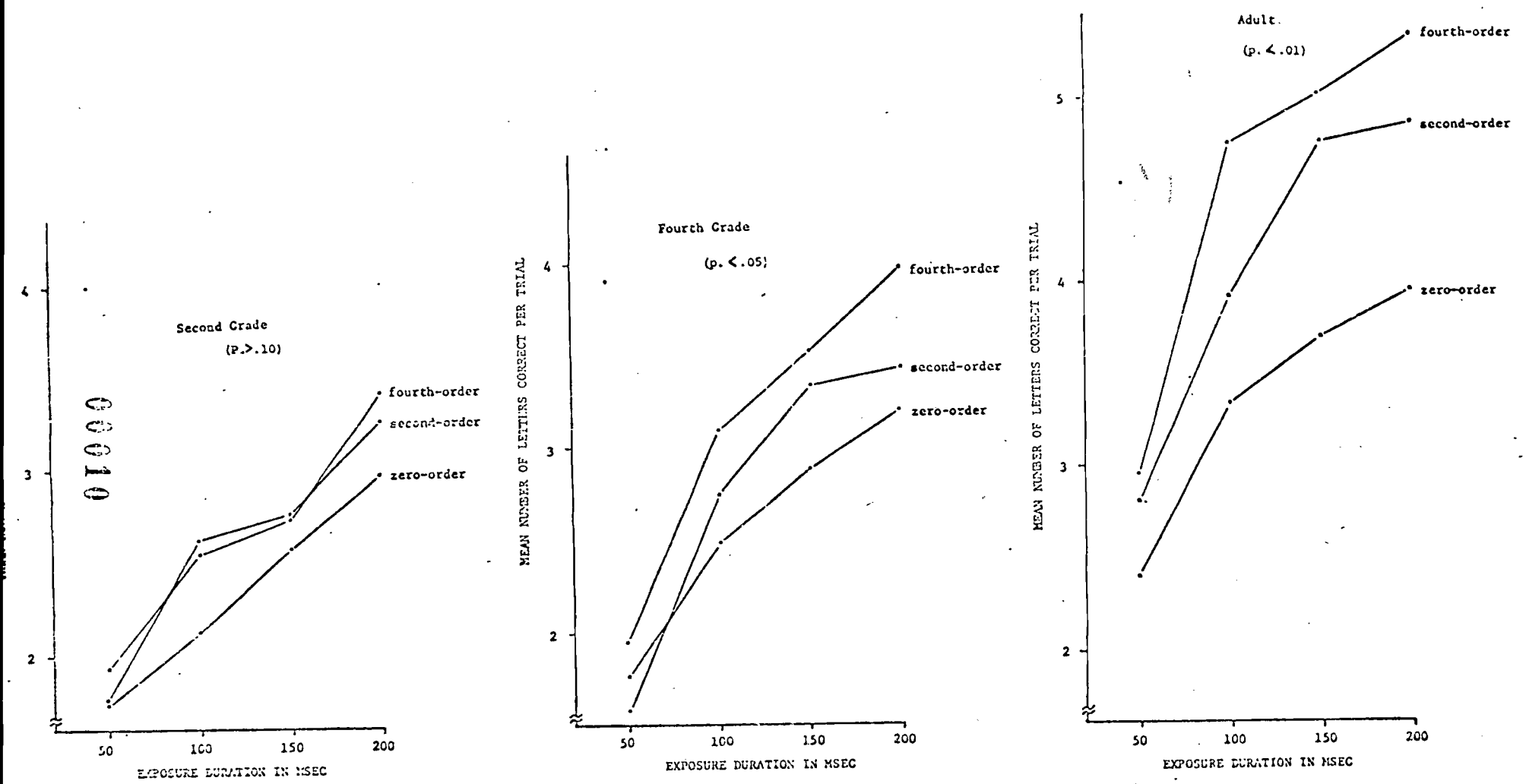


Fig. 3. Level of approximation X exposure duration interaction for each age group

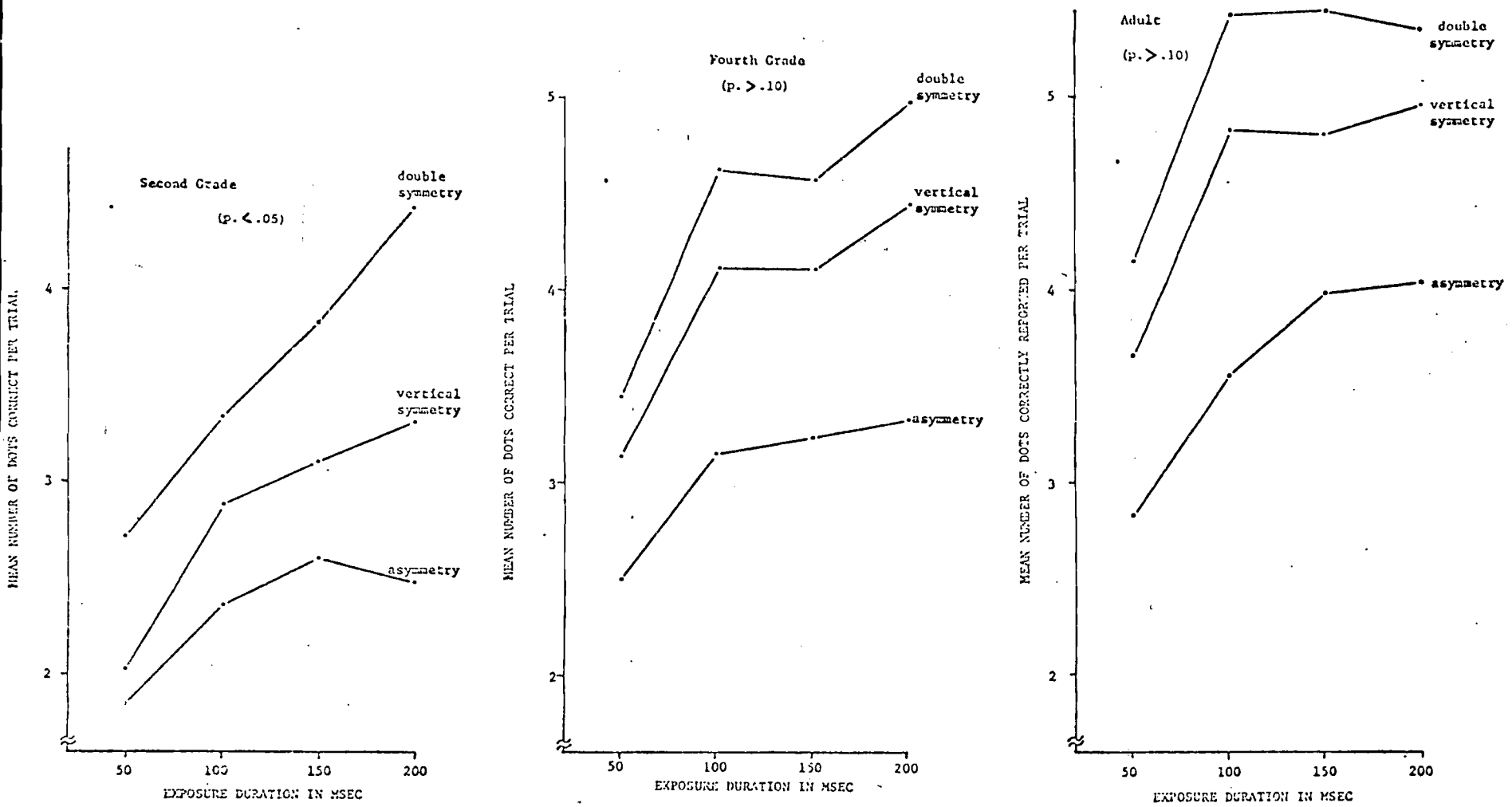
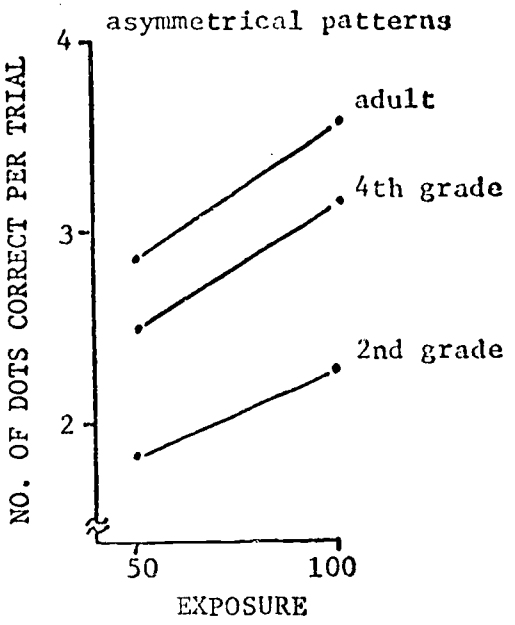


Fig. 4. Level of symmetry X exposure duration interaction for each age group.



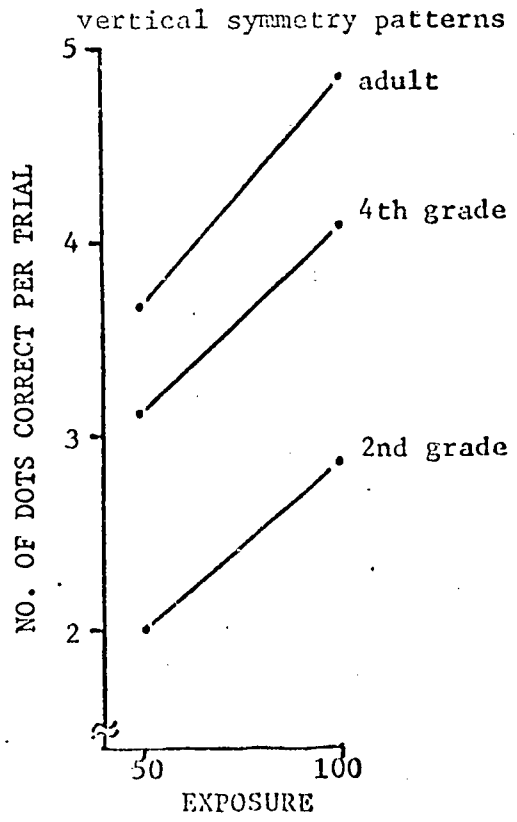


Figure 5. Age X Level of Symmetry X Exposure Duration Interaction from Analysis of Asymmetrical and Vertical Patterns at 50 and 100 msec (not significant).

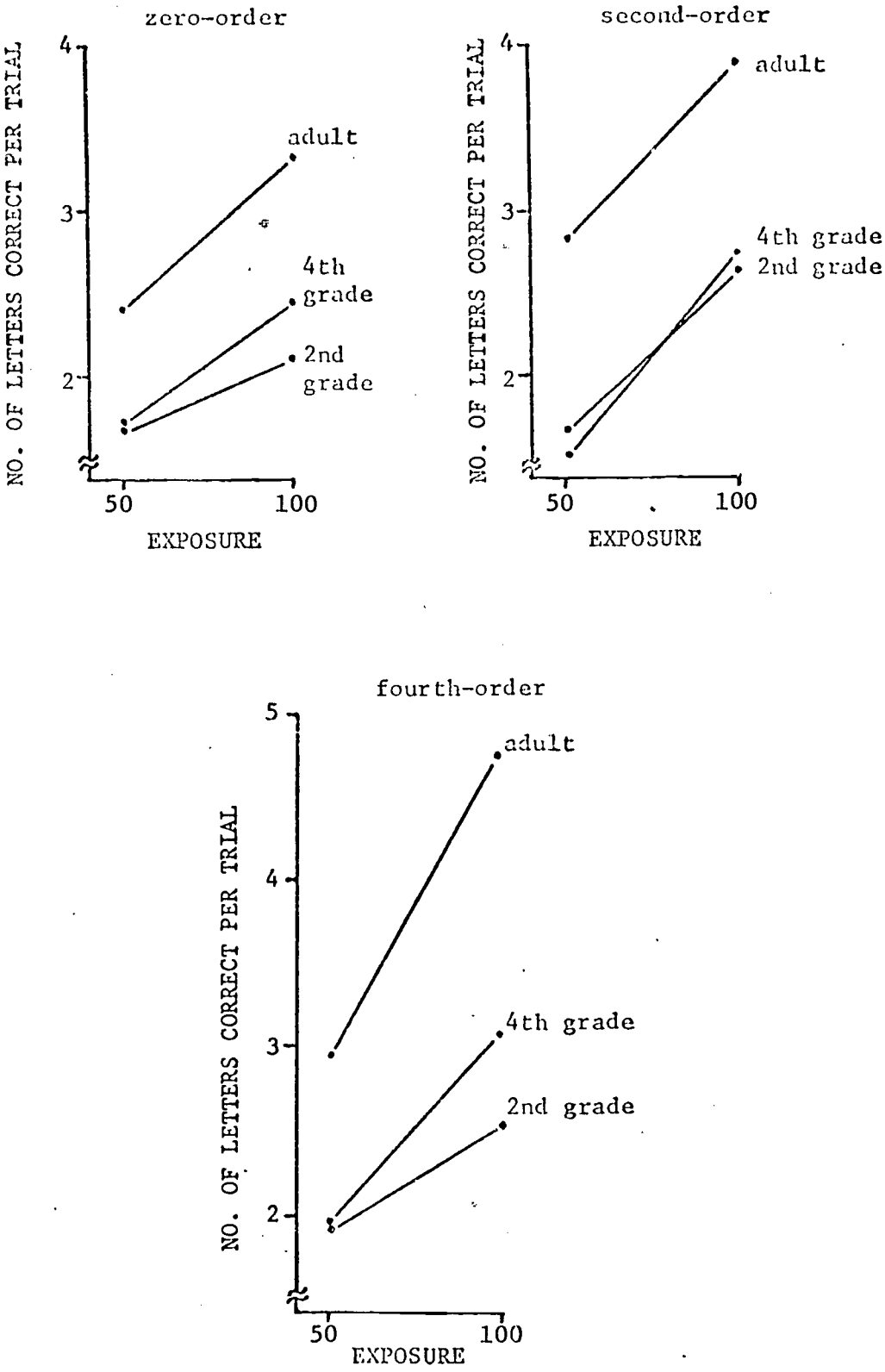


Figure 6. Age X Level of Approximation X Exposure Duration Interaction from Analysis at 50 and 100 msec ($p < .05$).

Footnote

[1]This paper is based on one experiment of a dissertation presented to the University of Colorado, August, 1974, in partial fulfillment of the requirements for the degree Doctor of Philosophy. Appreciation is expressed to Richard K. Olson, principal advisor, and to Carol Furchner and Susan J. Oldefendt for statistical advice.