DOCUMENT RESUME

ED 142 318 PS 009 429

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TITLE Peripheral Visual Processing.
PUB DATE Mar 77
NOTE 11p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (New Orleans, Louisiana, March 17-20, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Adults; *Age Differences; *Children; *Vision; *Visual Perception; *Visual Stimuli
IDENTIFIERS *Peripheral Vision

ABSTRACT

This study examined the hypothesis that the effective visual field of 5-year-old children is smaller than that of 8-year-old children and adults. In addition, an effort was made to determine whether task demands affect the size of the effective visual field and if so, whether the effects on performance are different for children and adults. A total of 54 subjects in three age groups (5-year-olds, 8-year-olds, and college adults) participated in one of three experimental conditions: (1) identification of a single geometric form located peripherally, (2) identification of a peripheral form presented simultaneously with a foveally located form which was to be ignored, and (3) identification of a peripheral form presented with a foveally located form, both of which were to be reported. The findings showed that a subject's ability to identify peripherally presented stimulus items was impaired by the presence of a foveally presented item whether or not the item required processing. Results also suggest that this interference by the foveal item was due to the tendency of older subjects to process this foveal item first. This tendency is apparently learned as it is not present in 5-year-old children. (JMB)

Peripheral Visual Processing*

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It is, of course, common knowledge that events are perceived not only in the area of central, or foveal, vision, but in the area of peripheral vision as well. A growing body of research has examined how well we are able to perceive these peripherally-occurring events. This research has delineated several variables which affect whether or not a stimulus in peripheral vision can be identified. One variable which has been found to affect the identifiability of peripherally located information is the presence of other stimuli in the visual field; subjects are less able to identify a peripheral stimulus when other stimuli are simultaneously presented than when the peripheral stimulus is presented alone. This task-induced shrinkage of the effective visual field has been called "tunnel vision" (Mackworth, 1965). It is not clear whether it is the actual processing of the additional stimuli, or their mere presence, which interferes with the subject's ability to visually process the peripheral stimuli. A second variable which has often been found to affect the size of the effective visual field is the age of the subject, with young children having somewhat more restricted fields of view.

*Paper presented at Society for Research in Child Development, New Orleans, March, 1977.

The main purpose of the present study was to investigate the hypothesis that the effective visual field of 5-year-old children is smaller than that of 8-year-old children and adults. In addition, we examined the questions of whether task demands affect the size of the effective visual field (i.e., "tunnel vision") and whether or not these task demands affect the performance of young children and adults differentially. The experiment therefore examined performance in three conditions of increasing difficulty: identification of a single geometric form located peripherally; identification of a peripheral form presented simultaneously with a foveally located form which was to be ignored; and identification of a peripheral form presented with a foveally located form, both of which were to be reported.

Five- and eight-year-old children and college adults were subjects in this study, 18 in each age group. Six subjects in each of these age groups participated in one of the three experimental conditions. The stimulus set consisted of 8 familiar geometric forms, one of which was presented at the fovea and/or at a peripheral location 1°, 2°, 4°, or 6° from center fixation. The peripheral stimulus was situated along the horizontal, vertical, or 45° diagonal axes. The stimulus materials for the Double Form conditions were the same as those in the Single Form condition, with the addition of a second geometric form in the center of each stimulus card which differed from the peripheral stimulus. A practice session was followed by the 8 experimental trials at each distance which were evenly distributed over two sessions. Stimuli were presented for 20 msec, and subjects were asked to report verbally the stimulus forms they had seen. In the Double Form Presentation condition, subjects were instructed to report only the stimulus figure that was "farther away", in contrast to the Double Form Report condition where both items were to be reported.

The results of this study are best understood by examining the effects of the three main variables: distance, age, and condition. All three of these variables have a significant effect on performance, and there is some indication that their effects may interact in fairly complex ways.

Let us first consider, then, the extent to which the performance of our subjects differs as a function of their age. Our data analysis reveals

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that the age of the subjects significantly affects performance: performance is higher for adults than it is for the 5- and 8-year-olds. However, as is often the case with developmental research, the finding of a significant main effect for age ir rather uninformative: are the children performing more poorly because they have poor motivation and attention? If the generally poorer performance of the children in this study involves their ability to perceive peripheral stimuli (rather than poorer motivation and attention), then this factor should be reflected in the presence of an interaction between age and distance. In other words, the performance of the youngest subjects should be affected more than that of the adults by presenting stimuli at increasing distances from the fovea. In this study, there was weak support for the presence of such an interaction. As a result, no clear conclusions can be drawn concerning the age by distance interaction.

The clearest and most interesting finding of this study is the effect of the different conditions on performance. Performance is highest when subjects see only a single stimulus item located peripherally. The two conditions where subjects simultaneously see both foveal and peripheral items are characterized by relatively low performance. Moreover, requiring subjects to actually process and report the foveal stimulus has relatively little impact on performance with the peripheral stimulus, although it does result in a slight reduction in this performance. Thus, it appears that the typical findings that central tasks interfere with peripheral visual processing are probably better interpreted in terms of the presence of the foveal stimuli than in terms of the requirement that the foveal stimuli be processed. It seems possible that subjects may actually fully process the foveal items regardless of whether or not they have been instructed to do so.

The study also suggests possible answers to the key question of why the simultaneous presence of a foveally presented item interferes with the processing of a peripheral item. It is generally assumed that the presence of the central item may somehow restrict the size of the visual field. This "restricted visual field" or "tunnel vision" argument implies that there should be an increase in the effect of the foveal item with increasing distance. An alternate hypothesis, however, is that the foveal item somehow draws the processing attention of the observer and, therefore, interferes with the processing of all other stimulus items in the field, regardless of their location. If this "general interference" hypothesis is correct, then the presence of the foveal item should have a fairly constant interference effect across all peripheral stimulus locations. The absence in our data of a significant interaction between Condition and Distance suggests that the general interference explanation may be the more accurate. Thus, our data suggests that the presence of a competing foveal item equally interferes with the processing of peripheral items, regardless of their actual distance or location.

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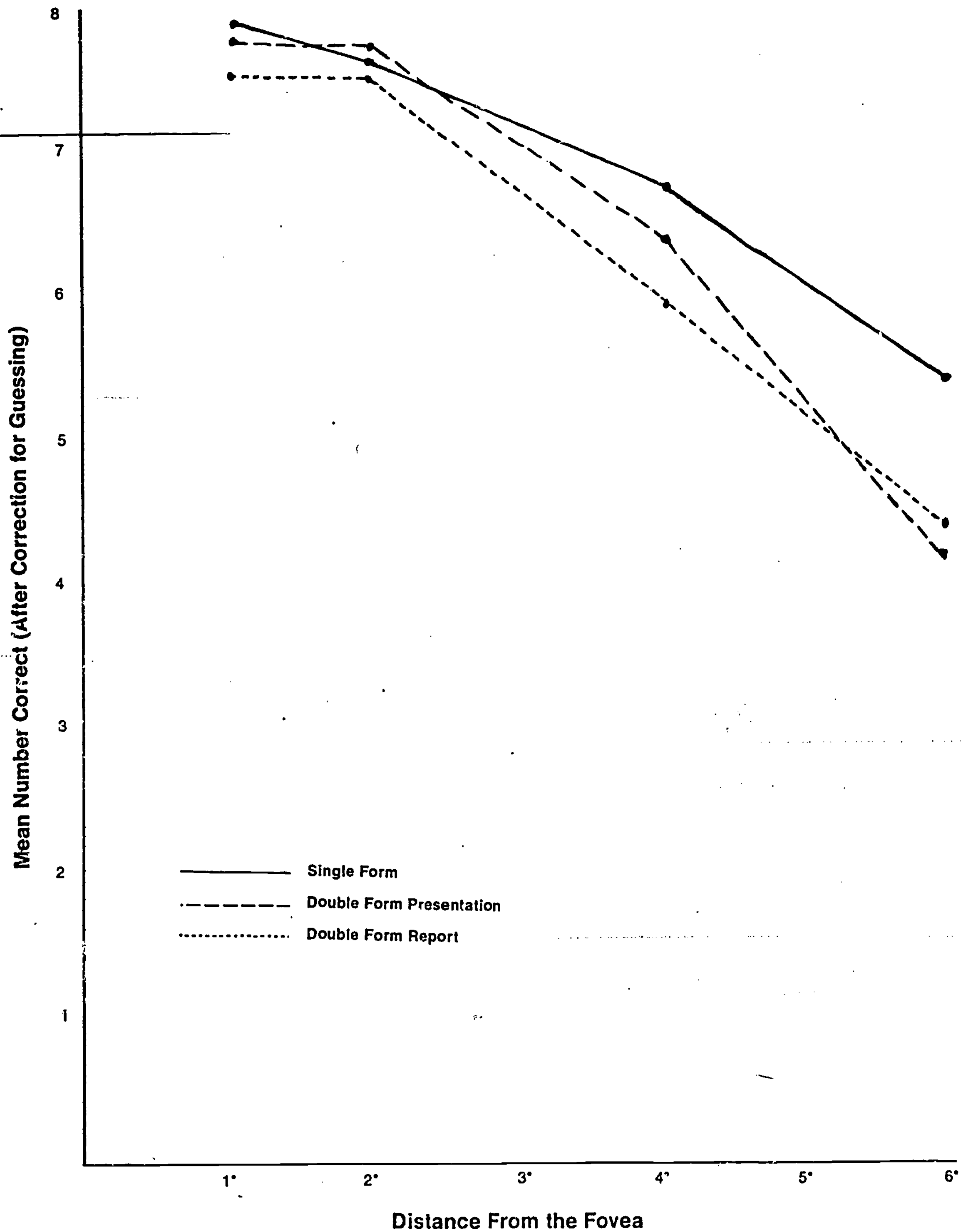
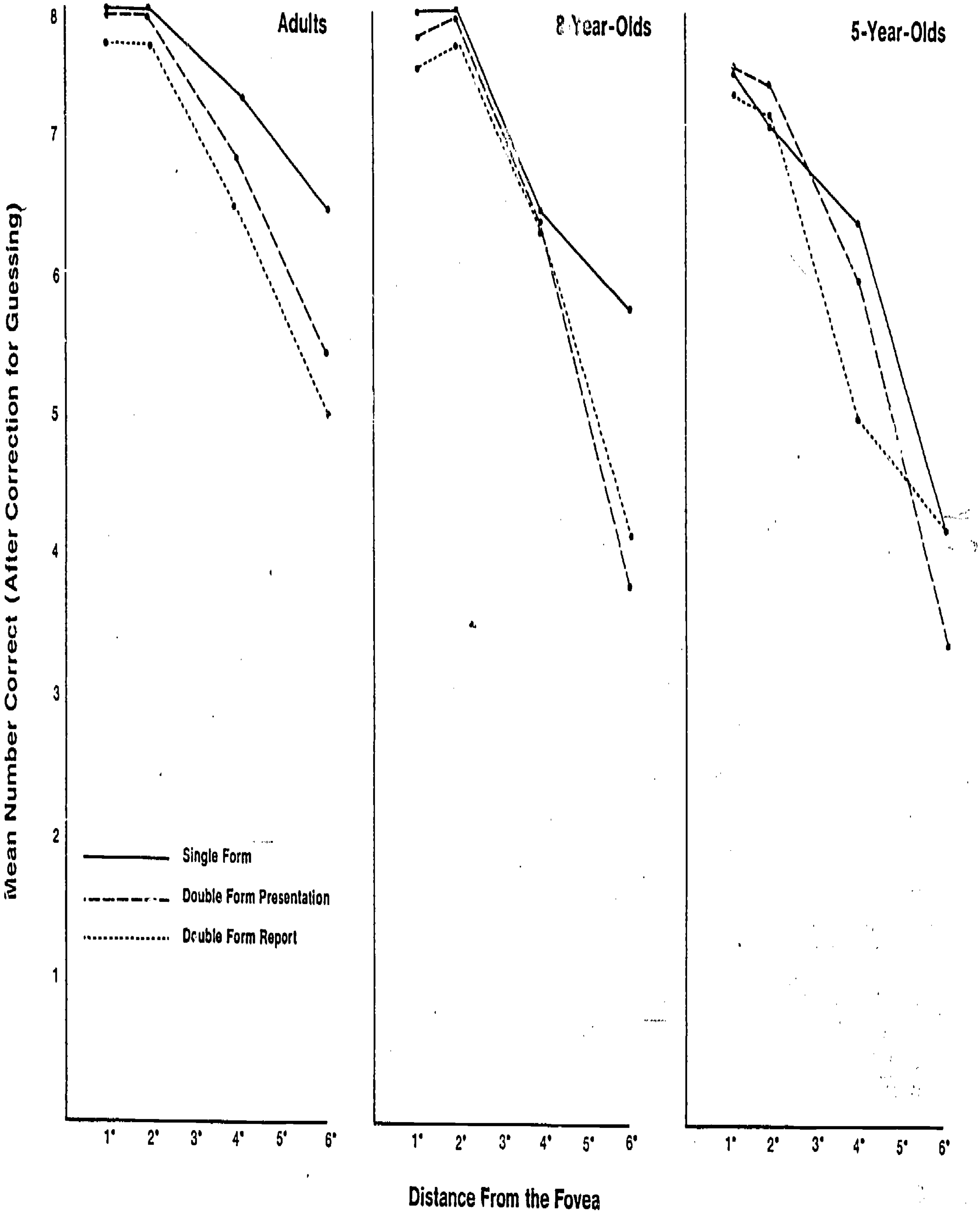
The next question that arises from this study is that of whether or not age is an important factor on performance. In attempting to answer this question, let us turn to the results of the planned orthogonal comparisons performed on the data obtained at 6° of visual angle. These comparisons were limited to the 6° data, since this was the greatest peripheral distance studied. It therefore seemed that any effects of condition would be most pronounced in the 6° data. The results of these comparisons do reveal that the different conditions appear to affect performance with peripheral stimuli items somewhat differently for each of the three age groups. Although neither the number of stimulus items nor the assumed difficulty of the task affect the performance of the 5-year-olds, the number of stimulus items in the display does appear to affect the performance of the 8-year-olds and the adults.

In particular, for the 8-year-olds and the adults, the presence of a foveal item interferes with the processing of the peripheral item <u>regardless</u> of whether or not actual processing of the foveal item is necessary. This finding is interpreted as evidence that adults and older children may be "locked in" to a processing strategy that directs them to process stimulus items from the center out, whether or not they have instructions to do so. This interpretation would argue as follows: when only a single item is presented to peripheral vision, performance is high, as total attention is directed immediately to it. When two items are simultaneously presented, the center one is processed first (even if it is irrelevant) so that only a fading trace of the rapidly decaying peripheral item remains by the time attention is directed to it. This interpretation is supported by an examination of the order in which items are reported in the Double Form Report Condition. For both the 8-year-olds and the adults, there is a definite tendency to report the foveal items first: only 21% and 14% of the correctly reported peripheral items are reported first by the 8-year-olds and the adults, respectively. This explanation also seems quite reasonable in light of the fact that our overall effect for condition is relatively constant and does not increase with distance. Thus, the amount of time taken to process the foveal item has about an equal effect on all peripheral stimuli.

In contrast, 5-year-old children do not show any pronounced effects of condition -- either in their overall data, or in their data at 6°. Moreover, the 5-year-olds do not appear to make use of an automatic "fovea first" processing strategy. Thus, the presence of a second item in the fovea does not interfere significantly with the 5-year-old's ability to recognize the peripheral item. Again, the lack of an obligatory "fovea first" processing strategy for the 5-year-olds is supported by the order of report data from the Double Form Report Condition. For the 5-year-olds, the order in which the items are reported is essentially random, with the peripheral item being reported first on 46% of the trials.

In conclusion, the findings of this study replicate the many existing studies which indicate that a subjects' ability to identify peripherally presented stimulus items is impaired when the subject must also process some foveally presented stimulus item. Secondly, this study supports Mackworth's notion that this impairment occurs whether or not the foveally presented item must actually be processed. More significantly, this study suggests that the use of the label "tunnel vision" for the phenomenon may be somewhat misleading, since the presence of the foveal stimulus seems to have an equal effect on all peripheral locations and does not really "restruct" the size of the effective visual field. This study further suggests that this interference by the foveal item is due to the automatic tendency of older subjects to process this foveal item first. Finally, it appears that this obligatory fovea-first processing strategy is somehow learned, as it is not present in children 5 years of age.


Mean Number Correct (After Correction for Guessing)
8
7
6
5
4
3
2
1
1°
2°
3°
4°
5°
6°
Distance From the Fovea
Single Form
Double Form Presentation
Double Form Report



Mean Number Correct (After Correction for Guessing)
8
7
6
5
4
3
2
1
Adults
8-Year-Olds
5-Year-Olds
Single Form
Double Form Presentation
Double Form Report
1°
2°
3°
4°
5°
6°
Distance From the Fovea