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ABSTRACT

This study investigated the effects of two stimulus manipulations (spatial distinctness and number of dimensions) on the performance of 24 kindergartners and 24 fifth graders in (1) tasks requiring distributed attention and (2) tasks requiring selective attention. Results suggest that kindergartners attempt to use one processing mode (distributed attention) regardless of whether the task demands focused or distributed attention. Fifth graders, on the other hand, vary their processing strategy to suit the task demands. (Author/MS)

A developmental study of attentional strategies

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It is well-established that young children have difficulty resisting distraction in tasks that demand focused attention (Gibson, 1969; Hagen & Hale, 1973; Wohlwill, 1962). Probably the least ambiguous demonstration of this effect involves the comparison of speeded responses in two conditions of information processing: in one of which irrelevant information is present, in the other of which it is absent. Using this comparison, at least three studies (Shepp & Swartz, 1975; Smith, Kemler & Aronfreed, 1975; and Strutt, Anderson, & Well, 1975) have shown that 5 and 6 year olds are more disrupted by the presence of irrelevant variation than are children four or five years older.

The experiments reported here are addressed to the nature of the young child's difficulty in such tasks. Specifically, our concern is with whether younger children's poor performance in the face of irrelevant variation is due to their inefficient use of the same processing strategies that older children use, or whether, in contrast, their poor performance indicates the use of quite different and particularly inappropriate processing modes. By the first account, both younger and older children are trying to focus on the relevant information and block out the distractor. Younger children are, however, much less successful. Thus, older and younger children are doing the same thing; older children are just doing it better.

By the alternative account, the younger children's greater distractibility is not due to their processing poorly but is rather due to their processing differently. For example, if the young child were not trying to focus on the relevant information, but was trying instead to distribute his attention between both the relevant and distractor information, we would expect the disruption result. The younger child's poorer performance with the addition of a distractor would be due to his trying to process two sources of information while the older child just processes one.

How could one demonstrate that younger children are using such a different and inappropriate strategy? One way is to show that experimental manipulations affect younger and older children's performances differently. The logic of this method is illustrated by analogy. Electric trolleys and busses both transport people about the city. By surface appearances alone, we might suppose that the mechanisms behind the movement were the same. This hypothesis, however, is disconfirmed by observing what happens under two levels of energy crisis. During a gasoline shortage, only the busses stop moving. In contrast, an electricity black-out stops only the trolleys. This interaction between type of transportation and type of energy crisis clearly shows that trolleys and busses have somewhat different operating principles. Similarly, if older and younger children employ different processing modes in selective attention tasks, their performances will be differentially affected by some manipulations.

In an earlier study (Smith, Kemler & Aronfreed, 1975), we observed just such an interaction. The experimental manipulation was type of distractor. During a constant relevant task, children made same-different judgments of successive poses of a stick figure. In one condition of distraction, a spatially separated border around the distractor was varied. In a second condition, the colors of the stick figures themselves varied. (Note that in this condition the relevant and irrelevant components are integrated into one object.) The surprising result was that whereas older children were less disrupted by the border than the color distractor, the youngest subjects (kindergarteners) performed reliably better when the colors varied. That the youngest subjects perform better in the condition in which older children perform less well, suggests that younger and older children use different processing modes.

We specifically suggested that while older children were attempting to use an appropriate focussing strategy, kindergarteners were initially processing the stimulus items as if distributed attention to both relevant and distractor information were required. This distribution hypothesis was suggested by the finding that the spatial separation of two sources impairs adult performance only when attention to both sources is required, as in a divided-attention task (see Treisman, 1969)

Two experiments were designed to test this post hoc explanation. The logic of the experiments is this: If younger children are distributing their attention in tasks which require focussed attention, than any manipulation that affects performances of all children in a divided-attention task will affect younger children's performances in the same manner in a selective-attention task. Thus the effects of spatial separation are assessed in two tasks: (1) when distributed attention to both sources is required and (2) when focussed attention to one source is the appropriate strategy. Our expectation is that increased separation will retard both older and younger children's performance in the divided-attention task but will impair only younger children's performance when one source is relevant. Note that there is no reason to expect that spatial separation impairs performance in selective attention tasks under the assumption that one is trying to focus but having di-ficulty doing so. However, the result is just what one would expect if young children initially apply the same stimulus-processing strategies to selective-attention and to division-of-attention tasks.

Method

Subjects

The subjects were students attending public kindergarten or fifth grade in a suburb of Philadelphia. Within each grade, 24 children were randomly selected to participate. Eight of these subjects were assigned to the division task and sixteen of them were assigned to the selection task. The mean age of the participating subjects was 5 yr 9 mo (range: 5-5 to 6-6) for kindergarteners and 10 yr 11 mo (range: 10-5 to 11-7) for fifth graders.

Stimulus Materials

For both selection and division tasks, the stimuli were schematic faces. Two dimensions varied within the faces: the eyes could be either open or shut; the mouth could be either turned up or turned down. Black and white reproductions of the faces were mounted on 4 in. by 6 in. white cards.

Two different decks of stimuli were constructed for the manipulation of spatial distinctness. For type T (Together) stimuli the eyes and the mouth were drawn within the same outline of a face. The T stimulus deck of 32 cards was composed of equal numbers of the four unique stimulus types resulting from the orthogonal combination of values of the eyes and mouth dimensions, with a single standard face outline per stimulus. The S (Separate) stimulus deck was identical to the T deck, except that each card contained two face outlines. The outline given on the right half of the card always contained one of the two values of the eyes dimension (and no mouth at all) and the outline given on the left half of the card always contained one of the two values of the mouth dimension (and no eyes at all).

Design

Each subject was assigned to one of the two tasks, division or selection, which he performed both on the T stimulus deck and the S stimulus deck.

Thus, spatial distinctness was manipulated within subjects, while the nature of the task was manipulated between-subjects.

Procedure

Each subject was tested individually. His task was to sort the decks as fast as possible without making an error. Each deck was sorted a minimum of 5 times. If more than two errors occurred on one of the final three sorts, that sort was repeated. A subject completed all sorts on one deck before receiving the second deck. The order of the two decks was counterbalanced across subjects.

Before sorting a deck, the subject was taught the response classifications by the experimenter who set out exemplars of each of the categories and provided appropriate category names. These differed according to task assignment and are detailed below. The subject was required to correctly name each exemplar twice within a haphazardly ordered set before proceeding to his first speeded classification trial.

The subject simply sorted the decks into spatially separated piles on a table. (No verbalizations occurred during the sorting.) Between sorts, the subject was encouraged always to go faster. Any errors committed on a sort were pointed out to the subject, and, if more than 5 were made on a trial, the pretraining was repeated.

The total experimental session lasted between 30 and 60 minutes.

Division task. The subject was instructed to sort the face stimuli into four categories, as follows: (1) "happy" -- eyes open, smiling; (2) "dreamy" -- eyes shut, smiling; (3) "grumpy" -- eyes open, frowning; (4) "weepy" -- eyes shut, frowning. Both relevant dimensions were pointed out explicitly to the subject.

Selection task. The subject was instructed to categorize the faces either according to the eyes dimension or according to the mouth dimension. Which dimension was relevant was counterbalanced within the group, and remained consistent across stimulus sets for the individual subject. When eyes were relevant, the categories were (1) "brighty" -- eyes open and (2) "sleepy" -- eyes shut. When mouth was relevant, the categories were (1) "happy" -- mouth smiling and (2) "grumpy" -- mouth frowning. That only one dimension was relevant was underscored in describing the required classification to the subject. Moreover, on type S sorts, the subject was told explicitly that he need only look at one side of the card to make his decisions, and that side was indicated to him.

Results

Division task. Each subject's sorting speeds were determined independently for the Separate and Together stimulus decks by taking the mean of his two fastest errorless sorts on each type of deck. For purposes of evaluating the effect of stimulus separation, each S was then assigned a difference score computed as speed (in seconds) on Separate deck minus speed (in seconds) on Together deck. Table 1 gives the means for the speed scores on each deck and for the difference scores between decks as a function of age level.

All sixteen subjects in the division-of-attention task sorted the Together deck more rapidly than the Separate deck. In independent tests, both the mean of the fifth-graders' difference scores and the mean of the kindergarteners' difference scores deviated from zero ($t(7) = 3.41$, $p < .025$, and $t(7) = 5.27$, $p < .01$, respectively). Thus, as expected, the effect of separating the two sources when subjects are required to distribute attention between them is to retard performance in both groups of children.

A t-test of the difference between age groups in the magnitude of their difference scores indicates a reliable age effect ($t(14) = 2.61$, $p < .025$).

However, the appropriate interpretation of this effect is not clear (Bogartz, 1976), since the kindergarteners are consistently slower than the fifth graders in both the Separate and Together conditions. Is the difference between sorting speeds of 60 and 90 seconds indicative of a larger effect of stimulus type than the difference between 40 and 60 seconds? In both cases, the effect of the manipulation is to increase sorting speed by 50%. In fact, when difference scores for subjects are computed by subtracting log speeds rather than raw speeds (a transformation under which differences in the above example are equivalent), the age effect disappears ($\underline{t}(14) = .07$). So calculated, the mean difference for kindergarteners is .28 and that for fifth graders is .21; each is different from zero ($\underline{t}(7) = 4.20$, $\underline{t}(7) = 3.99$, $\underline{p} < .01$ in both cases).

In summary, whether the effect of stimulus separation is measured as differences between raw speed scores or as differences between log-transformed speed scores, the result is that both kindergarteners and fifth graders distribute their attention more quickly to two sources that are "together" than to two sources that are "separate." The most conservative (and arguably, the most appropriate) further conclusion is that the two age groups are not differentially affected by the together-separate manipulation in the division task.

Selection task. The assessment of the sorting scores in the selection task was parallel in all respects to the series of analyses used for the division task. Both differences between raw scores and differences between log-transformed scores were examined. In the selection task, the conclusions are exactly the same for the two types of scores. The means of the raw speed scores in each condition and the difference scores computed on them are given in Table 2, separately for kindergarteners and fifth graders.

Statistical tests confirmed that the pattern of performance in the selection task conforms to expectations under the Distribution hypothesis. As was true for all subjects in the division task when distributed attention was required, kindergarteners in the selection task perform worse in the Separate than in the Together condition ($t(15) = 3.17$, $p < .01$, calculated on differences based on raw speeds; $t(15) = 3.62$, $p < .01$, calculated on differences based on log-transformed speeds). Also, as expected, fifth graders in the selection task show a different pattern. In their case, there is no effect of the manipulation of spatial separation on selection performance ($t(15) < 1.0$ based on differences between both raw scores and transformed scores). A direct comparison between the age groups strengthens these conclusions: the mean difference scores of kindergarteners and fifth graders are reliably different in the selection task, whether calculated on raw speeds ($t(30) = 3.21$, $p < .01$) or on log-transformed speeds ($t(30) = 3.16$, $p < .01$).

Thus, spatially separating the two sources of information -- one relevant and the other irrelevant in the selection task -- interferes with kindergarteners' performance, but has no effect on fifth graders' performance. The interference effect in kindergarteners is in exactly the same direction as the interference effect observed in all subjects when distributed attention was required.[1] Thus, the counterintuitive finding of Smith et al. is replicated and its explanation through the Distribution hypothesis is strengthened.

Discussion

The results clearly suggest that young children, under instructions to attend selectively, actively distribute their attention to both relevant and distractor information. The striking conclusion, is that, in some tasks at least, younger children's poorer performance is not due to their processing poorly but rather to their processing differently. Specifically, the younger children's poorer performance appears due to an actual attempt, on their part, to take in all the stimulus information. It should be noted, however, that the distribution hypothesis does not imply that young children are incapable of responding selectively. The kindergarteners did after all sort virtually errorlessly in the selective-attention task. Rather, by the distribution hypothesis, we are claiming that at initial stages of information processing, at the stage of information pick-up, young children distribute their attention where focussing would be more appropriate. It is this claim that the present experiments support. Note also that the finding that fifth-graders' performances are differentially affected by the manipulations in the selection and division tasks suggests that these older children use different strategies depending upon whether the task demands focussing or distributing attention. In contrast, the finding that kindergarteners' performances are similarly affected by the manipulations in the selection and division tasks suggest that these younger subjects use the same strategy in both situations. This conclusion is consistent with Pick and Frankel's (1974) proposal that one major trend in the development of selective attention is increasing flexibility in the use of attentional strategies. The suggestion is that older children are more efficient than younger children in adjusting their processing strategies to the task at hand. The present results refine this notion: kindergarteners attempt to use one processing mode -- distributed attention -- regardless of whether the task demands focussed or distributed attention.

Is the kindergartener's use of an inappropriate strategy in the selection task merely due to his inability to understand that only part of the incoming information is relevant to correct responding? If this question is to imply that simply modifying the instructions would produce more optimal strategies, we think it unlikely. First, the instructions that we did employ in the selection task were explicit on the point that only one dimension was relevant. For example, a subject in the selection task with a type S deck was told: "When there's a smile, it's Happy and when there's a frown, it's Grumpy. You only have to look to see if there's a smile or a frown to know who it is, and you only have to look on this side. See, the smiles and the frowns are only on the faces on this side. You only have to look here to know who it is." We find it hard to imagine instructions that more strongly encourage selective processing. Second, the fact that even young subjects committed very few errors of classification from the very first trial argues for the success of our instructions in communicating the requirements of the selection task.

However, the results of the present study do not speak to the interesting question of whether, how much, or what kind of training of kindergarteners might be successful in bringing them to adopt a focussing strategy in the selection task. Clearly, focussing is not kindergarteners' preferred strategy in selection tasks, but we should not dismiss the possibility that it may still be within their repertoire or easily added to their repertoire. Some attempts at training are called for.

To conclude, the present results suggest that in some selective-attention situations, younger children's poor performance is due to their use of a particularly inappropriate strategy. Specifically, at initial stages of information pick-up, these younger subjects distribute their attention to both relevant and distractor information.

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Footnotes

[1] A direct comparison of the sizes of the interference effects for kindergarteners in the division and selection tasks is not justified because the requirements of the two tasks are so very different. In the division task, for example, subjects must sort into 4 categories; whereas in the selection task, they must sort into 2.

Table 1

Results from the division-of-attention task as a function of age level: mean speed scores on the two types of stimulus decks and mean difference scores (Separate minus Together) computed on them.

	Speed Scores		Difference Scores
Grade.	Together Deck (T)	Separate Deck (S)	S minus T
K	69.94	92.75	22.81
5	40.19	50.06	9.87

Table 2

Results from the selective attention task as a function of age level: mean speed scores on the two types of stimulus decks and mean difference scores (Separate minus Together) computed on them.

	Speed scores		Difference scores
Grade	Together Deck (T)	Separate Deck (S)	S minus T
K	47.36	52.53	5.18
5	27.28	26.92	-.36