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ABSTRACT

Children of ages 5 and 8 years were given one of three learning tasks: (a) a component selection problem, in which two stimulus components were redundant and (b) two incidental learning tasks, in which one component of the stimuli was task-relevant and the other was incidental. A posttest, measuring the children's recall for information about each component separately, was assumed to reflect the degree of attention directed to each component during learning. Attention to the nondominant component was found to increase with age when this feature was redundant with the dominant component and could thus serve as a second functional cue (component selection task), but not when it was incidental. These results suggest a developmental increase in the flexibility of attention deployment, as the tendency for children to exercise selective attention varies with the requirements of the task. (Author)

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RESEARCH BULLETIN

AGE DIFFERENCES IN CHILDREN'S PERFORMANCE ON MEASURES OF COMPONENT SELECTION AND INCIDENTAL LEARNING

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Abstract

Children of ages 5 and 8 years were given one of three learning tasks: (a) a component selection problem, in which two stimulus components were redundant and (b) two incidental learning tasks, in which one component of the stimuli was task-relevant and the other was incidental. A posttest, measuring the children's recall for information about each component separately, was assumed to reflect the degree of attention directed to each component during learning. Attention to the nondominant component was found to increase with age when this feature was redundant with the dominant component and could thus serve as a second functional cue (component selection task), but not when it was incidental. These results suggest a developmental increase in the flexibility of attention deployment, as the tendency for children to exercise selective attention varies with the requirements of the task.

AGE DIFFERENCES IN CHILDREN'S PERFORMANCE ON MEASURES OF COMPONENT SELECTION AND INCIDENTAL LEARNING[1]

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Educational Testing Service

Various theoretical analyses have stressed the role of attention in children's learning, suggesting that developmental improvement in learning ability is partly attributable to an increase in the efficient use of selective attention (Gibson, 1969; Hagen & Hale, in press; Maccoby, 1969). One aspect of this issue concerns children's ability to distinguish between situations in which it is functional to attend selectively and those in which it may be advantageous to attend more broadly. For example, attention to an extraneous stimulus feature in an incidental learning task is clearly nonfunctional, and it is to a subject's advantage to ignore such a feature and attend selectively to task-relevant information. On the other hand, if a stimulus component is redundant with other features, then attending to all features can enhance the discriminability of the stimuli and thereby facilitate performance. Data from Hale and Morgan (1973) suggest the hypothesis that, as children grow older, they tend increasingly to distinguish between these two situations, deploying attention in a manner that best fits the demands of the task. To provide a further test of this hypothesis, the present study examined 5- and 8-year-old children's performance on tasks differing in the degree to which one of two stimulus components was extraneous to the purposes of the task. The study included a component selection problem, in which the stimulus components were redundant and could both serve as functional cues, in comparison with two types of incidental learning task, in which one stimulus feature was defined as incidental. Separate comparisons were performed for each of three types of stimulus material.

Method

Subjects

The total sample included 149 subjects at age 5 (mean = 5.6 years) and 147 subjects at age 8 (mean = 8.7 years), drawn from elementary schools in a middle-class area of Bucks County, Pennsylvania. The subjects were divided among the various experimental subgroups as specified below in the section on Experimental Design.

Materials

Colored shape condition. The primary materials for this task were colored shapes, each approximately 7½ cm square, placed on black cards, 9 cm wide by 13 cm high. The shapes were circle, square, triangle, heart and star, and the colors were blue, green, orange, yellow and pink.

Colored picture condition. This task used simple colored representations of common objects, each approximately 5½ cm square, placed on black 9 cm by 13 cm cards. The objects were sock, rowboat, ball, chair and cup, and the colors were the same as those used for the colored shapes.

Patterned shape condition. This condition employed white geometric shapes on black cards with a pattern superimposed on each shape. The shapes were the same as those used in the colored shapes condition, and the patterns were stripes, checks, dots, waved lines and dashed lines.

Procedure

For convenience, the procedure will be described in terms of the colored shape condition. An analogous procedure was followed for the colored pictures and the patterned shapes, and descriptive terms appropriate to these conditions will be included in parentheses where necessary.

<u>Component selection task</u>. The subject was seated at a table across from the experimenter, and between them was a transparent plexiglas screen (11 cm high by 56 cm wide). Five "display cards" were rested against the screen in a row facing the experimenter, each card containing a different colored shape (colored picture, patterned shape). The display cards were turned facing the subject, and the entire array was exposed for five seconds, following which the cards were again turned facing the experimenter. "Cue cards" identical to the display stimuli were then presented one by one above the screen and, for each of these cues, the subject was required to point to the (back of the) display card identical to that being shown. Each time the subject made his choice the correct display card was turned and shown briefly in its position (note that the display cards remained in the same positions in the row throughout the task). The cue cards were arranged by trials--a trial containing each of the five stimuli--with a different random order of stimuli in each successive trial. The task continued to a criterion defined as either (a) two errorless trials in succession or (b) two errorless trials with an intervening trial containing a single error. The two components of the stimuli were redundant in this task, so that either or both components could serve as functional cues for learning.

After the subject had reached criterion, a posttest assessed his memory for the position associated with each component separately. The display cards remained against the screen facing away from the subject and no feedback was given. Test stimuli were presented, one by one, each consisting of a colored card or a white shape on a black card (or white picture on a black card, or white card with a pattern). For each test stimulus the subject was

required to point to the display card that contained a shape or a color like that being shown. Every shape and color was presented, and the two components were systematically intermixed across test trials. The number of correct responses was determined for each component separately, yielding a "shape score" and a "color score" for each subject (or picture and color scores, or shape and pattern scores). These component scores are assumed to reflect the degree to which attention has been directed to each of the stimulus components during the learning phase. Thus, if a subject obtains a perfect score for one component and a chance-level score for the other, he has presumably attended selectively to the first component as he learned the task; however, to the extent that he recalls information about both features, his attention has been less selective, as he has attended to a combination of the two components.

Incidental learning 1. This task was identical to that described, except that the cue cards in the learning phase contained white shapes (or white pictures) on black backgrounds. As each cue was shown, the subject was told to point to the display card with the same shape. Thus, color (or pattern) was designated as "incidental" and could not serve as a functional cue for learning.

Incidental learning 2. The procedure used here was identical to that for incidental learning 1 except that, on the cue cards, each shape varied in color (pattern) from trial to trial. Across trials, a given shape appeared in all of the colors except the color with which it was associated in the display. As each cue was shown, the subject was told to point to the display card with the same shape. Thus the incidental component,

color (pattern), served as an "irrelevant dimension" as the term is typically used in research on discrimination learning, and attention to it would clearly be detrimental to successful task performance. A posttest identical to that described for component selection followed the learning phase for the incidental learning tasks, yielding scores indicating the number of correct responses for each stimulus component.

Each task was preceded by a pretraining task similar to the learning phase but with only two stimuli and one trial. The shapes and colors used for pretraining (pictures, patterns) were different from those of the main task. At the end of pretraining, the experimenter placed each cue card next to its corresponding display card, saying "so you see, this one (cue 1) is like this (display 1) and this one (cue 2) is like this (display 2)." This last procedure, although followed for all three tasks, was intended to emphasize the relevance of shape in incidental learning 1 and 2.

Experimental Design

The design of the study was defined by the combination of the variables Age (5 and 8 years), Material (colored shapes, colored pictures, patterned shapes) and Task (component selection, incidental learning 1, incidental learning 2), to yield 18 subgroups. Each of these groups contained 16 subjects, after exclusion of 5 of 149 subjects at age 5 and 3 of 147 subjects at age 8 for failure to reach criterion within 12 trials. Each group contained an equal representation of (a) the two sexes, (b) two stimulus sets, differing in the color (pattern) associated with each shape (picture), (c) two arrays of display cards, (d) two orders in which the cue cards were presented, and (e) two orders in which the test stimuli were presented.

Results

Component Scores

As observed in earlier studies using similar materials (Hale & Morgan, 1973; Hale & Taweel, in press), the subjects directed their attention primarily to shape rather than color, as only two of the 96 subjects given the colored shape materials failed to achieve a shape score higher than, or equal to, their color score (none in the component selection task). Analogously, for only 3 subjects given the colored pictures was the picture score lower than the color score (all 3 in the component selection task) and for only 6 subjects given the patterned shapes was the shape score lower than the pattern score (5 in the component selection groups). Thus, the shape and picture components were dominant, in the sense that the subjects directed the majority of their attention to these attributes, while color and pattern were secondary features.

The results of principal interest involve differences among tasks in the component scores. Figure 1 presents the mean component scores for the three tasks, separated by age and type of material. It can be seen that the scores for the dominant component (shape or picture) were uniformly high, and analysis of variance of these scores, with Age, Material and Task as variables yielded only an effect of Age ($\underline{F}(1,270) = 5.34$, $\underline{p} < .05$).

Insert Figure 1 about here

For the nondominant component (color or pattern), on the other hand, the pattern of scores varied considerably across tasks; the scores increased markedly for the component selection task with all three types of material but showed no consistent increase for the incidental learning tasks.

Analysis of variance of these scores, with Age, Material and Task as factors, yielded a near-significant interaction between Age and Task ($F(2,270) = 2.71$, $p = .07$) along with main effects of Age ($F(1,270) = 7.85$, $p < .01$) and Task ($F(2,270) = 13.26$, $p < .001$). The Task factor was then divided into two orthogonal contrasts, reflecting the questions of interest in the study: Component selection vs. incidental learning overall, and incidental learning 1 vs. incidental learning 2. Separate analyses of variance (for the nondominant component) were performed with Age, Material and each contrast as factors. In the first analysis, the interaction between Age and component selection vs. incidental learning proved to be significant ($F(1,270) = 5.30$, $p < .05$) along with the overall effects of Age ($F(1,270) = 7.85$, $p < .01$) and component selection vs. incidental learning ($F(1,270) = 25.40$, $p < .001$). No effects were significant in the analysis involving the contrast between incidental learning tasks. The simple effect of Age was significant for the component selection task ($F(1,270) = 12.23$, $p < .001$) but not for either incidental learning task ($F < 1$). Thus, the children's recall of nondominant stimulus information--i.e., that to which attention was not primarily directed--tended to increase with age when that information was redundant with the dominant feature but not when it was incidental or irrelevant. It must be pointed out, however, that the component scores were above the chance level of one correct response in all groups (smallest $t(15) = 2.98$, $p < .01$), indicating that in no instance was the nondominant component totally ignored.

Learning Data

Table 1 presents the mean number of errors in the learning phase for each group. One of the most striking aspects of these data is the relatively consistent rank-ordering in difficulty of tasks; the number of errors was greater for incidental learning 1 than component selection in all cases, and greater for incidental learning 2 than incidental learning 1 in five of the six instances. An analysis of variance performed on these scores, with Age, Material and Task as factors, yielded a significant main effect of each factor (Age: $F(1,278) = 13.26$; Material: $F(2,278) = 7.08$; Task: $F(2,278) = 9.27$, all $p < .001$) while no other effects reached significance.

Insert Table 1 about here

Discussion

Evidence from research on incidental learning has implied that, as children grow older, they tend increasingly to employ selective attention as their characteristic approach to a learning task (e.g., Hagen, 1967; Maccoby & Hagen, 1965; Siegel & Stevenson, 1966). This conclusion actually has been derived from a situation in which it is most efficient for a child to adopt a selective orientation--one in which only certain stimulus features can serve as functional cues. An unanswered question in these studies is whether the older child is naturally predisposed to focus his attention on selected aspects of stimuli or whether he is simply showing an accommodation to the attentional demands of the task. According to the present evidence (and data from Hale & Morgan, 1973), the latter interpretation, in fact, may be the more accurate of the two alternatives. This becomes

clear if one examines the role played by the nondominant stimulus feature in each of the three tasks used here. In the component selection problem, this feature was redundant with the dominant component, so that the children were free to discriminate among the stimuli in whatever way they chose--on the basis of a single component or on the basis of a combination of features. In this case, attention to the nondominant as well as the dominant stimulus feature could be useful, in that it could aid the subject in discriminating among the stimuli. On the other hand, the incidental learning tasks called for a selective approach, in that the nondominant stimulus feature was defined as extraneous, and attention to that feature could serve no useful purpose. The results indicate that, as children grow older, they tend increasingly to differentiate between these two situations, deploying attention in a manner that best fits the requirements of the task. Only when the nondominant component was redundant with the dominant feature, and could serve as a functional secondary cue, was there a consistent increase with age in the children's attention to this component.

The learning data provide additional information regarding the role of the nondominant component. The tasks generally rank-ordered from incidental learning 2 as the most difficult task to component selection as the least difficult. Thus, the assumptions regarding the relationship among these tasks appear correct; the detrimental effect of the nondominant feature indeed decreased across tasks from incidental learning 2, in which this feature was defined as incidental, to component selection, in which it was redundant with other information. These results also indicate that at least some attention was paid to the nondominant component in all groups. That is, for color or pattern to have produced any differences in

learning scores, the subjects cannot have totally ignored this component as they learned the task, a conclusion that is also indicated by the above-chance color and pattern scores in all cases. Thus, no group exercised selective attention to the extent that they completely shut out information about color or pattern; rather, the differences between gro[illegible] to have been in the relative degree to which selective attention was employed.

The fact that the present results were observed with a variety of materials attests to the generality of the conclusions drawn here. Of course, it could still be argued that the materials used in this study represent a restricted range of possibilities, in that the stimuli in each case consisted of integrated components. That is, for each of the three types of material, the two components were features that were integrally contained within a single unit rather than, for example, elements that were spatially separate from each other. There were two basic reasons for restricting the variation in mate ials ir this manner. First, integrated materials may be functionally dissimilar from nonintegrated stimuli, with regard to measuring children's selective attention; in a recent study, the developmental trends in children's incidental learning were found to differ considerably for stimuli contrasting in degree of integration among components (Hale & Piper, in press). Secondly, it was felt that the questions of the present study were most appropriately asked in connection with integrated materials. The dimensions of difference among stimuli of this sort--shape, color, pattern, etc.--are features that typically define the difference between objects and serve as a basis for identifying them. Thus, this is the type of material with which it seems most appropriate to address the question

"To what extent do children attend to each of several features in differentiating among stimulus objects?"

Whether the present conclusions also apply to nonintegrated stimuli is a question that is currently under investigation. However, with respect to integrated materials at least, the implications of the present evidence are clear: as children mature, they do not use an increasingly more selective approach in all learning situations. Rather, as Hagen and Hale (in press) have emphasized, children become more flexible in their deployment of attention, differentiating between situations in which it is advantageous to attend selectively and conditions under which it can be more useful to broaden their scope of attention to include several types of stimulus information. Children thus show an increasing capacity to accommodate to the attentional demands of a learning situation, not only improving in ability to attend selectively but also becoming better able to determine when it is most appropriate to employ selective attention.

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Footnote

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Table 1

Mean Errors in the Learning Phase for Each Subgroup

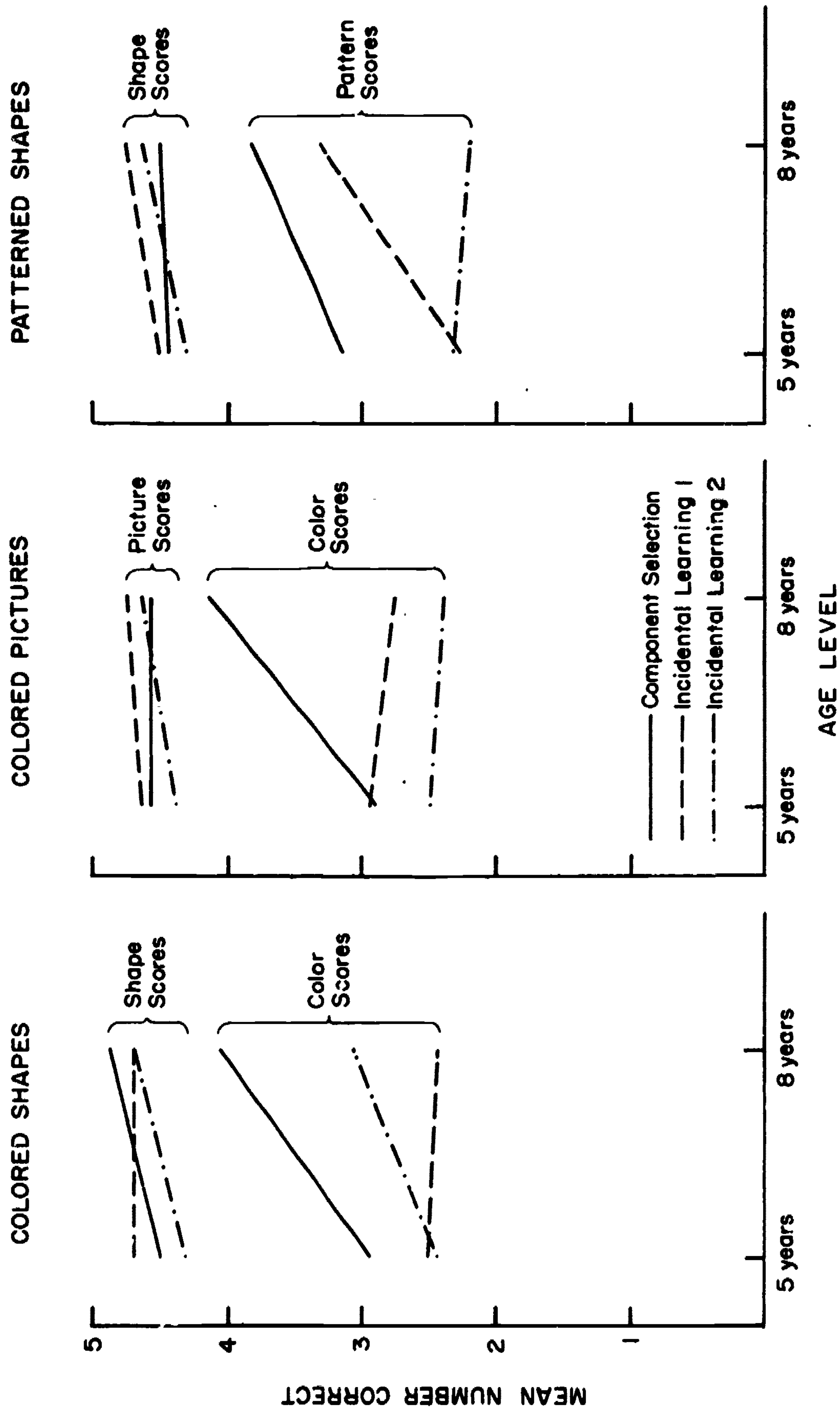
(Standard Deviations Are in Parentheses)

	5-year-olds			8-year-olds		
	Component selection	Incidental learning 1	Incidental learning 2	Component selection	Incidental learning 1	Incidental learning 2
Colored shapes	2.38 (2.42)	4.25 (3.66)	7.63 (6.10)	1.25 (1.44)	2.94 (5.52)	1.81 (2.59)
Colored pictures	1.88 (2.34)	2.38 (2.22)	3.29[a] (5.18)	1.25 (1.95)	2.77[a] (5.47)	3.29[a] (6.50)
Patterned shapes	4.13 (4.23)	5.50 (5.53)	8.25[b] (6.65)	2.38 (2.36)	3.13 (3.46)	4.82[a] (4.23)

Note: Represented here are the mean number of errors prior to the beginning of a criterion run for each group, including subjects who failed to learn. Thus, *N* = 16 in each group, except: [a]*N* = 17, [b]*N* = 20.

Figure Caption

Fig. 1. Mean number correct in posttest for each component.


COLORED SHAPES
COLORED PICTURES
PATTERNED SHAPES
Shape Scores
Color Scores
Picture Scores
Color Scores
Shape Scores
Pattern Scores
Component Selection
Incidental Learning 1
Incidental Learning 2
MEAN NUMBER CORRECT
1
2
3
4
5
5 years
8 years
AGE LEVEL