DOCUMENT RESUME

ED 127 039 PS 008 777

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TITLE Scanning Behavior in a Classification Task.
PUB DATE [74]
NOTE 17p.

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Age Differences; *Classification; *Cognitive Development; *Dimensional Preference; *Early Childhood Education; Grade 1; Middle Class; Preschool Children; *Research
IDENTIFIERS *Components of Cognitive Competency Program

ABSTRACT

This study investigates the developmental changes that occur in the attending behavior of children engaged in a relatively simple classification task, and attempts to reaffirm the existence of developmental changes in stimulus preferences and in the ability to employ double classification systems. Subjects were 24 preschool and 24 first grade children from a middle class suburban school district. The children were presented with 18 geometric forms arranged in a 5 x 5 matrix and asked to collect all the stimuli that went together and then to state how the stimuli were the same. After the child had completed the first trial, the stimuli were rearranged and the child was reminded of the basis of his first collection and asked to put the stimuli together in another way. A scoring scale was constructed based on the use of the horizontal plane and the use of a single stimulus attribute at a time. In general, data tend to reaffirm the existence of developmental changes in stimulus preference, and indicate a significant age effect in scanning behavior. Findings also support the expected hierarchy of dimensional preferences: form, color, size. Relatively few children generated double classifications. All of the older children were able to classify on the basis of form and color and 75% classified on the basis of size. The younger children were unable to classify on the basis of size and, as expected, showed a less clear preference for form as a stimulus dimension. (SB)

Program Title: Components of Cognitive Competency

Work Unit: Scanning Behavior in a Classification Task

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SCANNING BEHAVIOR IN A CLASSIFICATION TASK

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This study is concerned with certain presumed developmental changes that occur in the attending behavior of children while engaged in a relatively simple classification task. A secondary concern of the study was to reaffirm that there are developmental changes in stimulus preferences and in the ability to employ two-way (double) classification systems.

Interest in attending behavior is relatively recent (Trabasso and Bower, 1968) and is conceptually concerned with those variables, presumably cognitive, that mediate performance on varieties of tasks, especially discrimination learning and classification tasks. The general model permits both experimental as well as descriptive research; that is research that examines the interaction between cognitive demands (stimulus characteristics) and subject characteristics (organismic states). Significant contributions to this literature have come from Piaget (1969), Olson (1970) and the Russian Psychologists, especially Sokolov (1963). In a most general sense, these theorists have argued that there is a systematic development of perceptual strategies that children employ given a specific task demand. It is unclear from these theoretical positions how perception and cognition interact; that is, are changes in perceptual behaviors a reflection of changes in cognitive structures (competencies) or are perceptual acts and perceptual development isomorphic to cognition? It would seem that the issue here is similar to that raised by Furth (1966) with respect to the relationship between language and cognitive development; is language the reflection of cognition or is language the sine-qua-non of cognition? With respect to perception, it does not seem likely that the problem can be empirically resolved because the tasks employed to determine cognitive growth (the various conservation tasks for example) also involve sensory (perceptual) inputs. The question of separating these systems seems futile. A perhaps better conceptual strategy is to accept the notion that domains of competencies are interrelated (to a greater or lesser degree) and that change in one domain occurs in harmony with the other domain and influences the growth in the other domain. Essentially, this is the view taken by Olson (1970) and Meyer and Dwyer (1974). Elkind (1969), however, in his extensive work on decentration adheres to Piaget's somewhat vague notion of a "partial isomorphism" between perceptual processes and cognition. Despite these ambiguities there is an accumulating body of data demonstrating that the visual strategies used by children change in systematic ways with increasing age (Mackworth and Bruner, 1970; Olson, 1970; Vurpillot, 1968; Zinchenko, Chzhi-Tsin, and Tarakanov, 1963; Mackworth and Otto, 1970; O'Bryan and Boersma; 1971; and Meyer and Dwyer, 1974). These studies generally indicate that younger children are apparently less systematic in their explorations of stimuli and that their behavior is governed more by the perceptual characteristics of the task than its more inferential cognitive features. In the foregoing studies, very precise eye movement recordings were made providing the investigators with detailed descriptions of the children's fixations and patterns. The research reported in this study employed a comparatively gross system but one nevertheless adequate to the purposes of the study; namely the sequence of stimulus selections used by children at two age levels. It was assumed that for the developmentally more complex tasks, the children would demonstrate different selection patterns and that these variations would occur both between age groups and within age groups.

There is a literature that extends back quite far with respect to changes in children's preferences for stimulus dimensions. Brian and Goodenough (1929) found that children grouped stimuli in terms of form prior to age three, then from three years through six years grouped in terms of color, and finally returned to form. They did not find sex differences. Kagan and Lemkin (1961), using children ranging in age from 3-9 to 8-6, and comparing sex, found that all the children preferred form to color and color [illegible] size; in fact, size was rarely selected by the children. The results did suggest that older girls preferred color more than older boys, but the authors could not offer a firm explanation for this finding. The preference for form was shown in a study by Smiley and Weir (1966) who were primarily interested in developing a procedure for reliably determining stimulus preferences among children for use in other studies (reversal-non-reversal shift, for example) where it was thought that stimulus preference might have a direct influence on the outcomes of those experiments. It seems reasonable to conclude from these data that children do possess preferences for stimuli, that these preferences are related to age, and in all probability to level of cognitive functioning.

The development of double classification skills, the ability to simultaneously group stimuli on two or more dimensions, has received considerable attention in the research literature (Kofsky, 1966; Inhelder and Piaget, 1964; Shantz, 1967; Parker and Day, 1971; Parker, Rieff and Speer, 1971). One of the primary procedures involves the use of a matrix which combines two dimensions and leaves a cell open. The child is given several stimuli and selects one with which to fill the open space; one stimulus contains one of the single attributes, a second the second single stimulus, the third contains both stimuli, and finally random stimuli are included. This task is quite difficult and is not readily achieved until approximately age ten years. The procedure used in this study is not nearly as structured as in the matrix procedure and should, therefore, be more difficult for the children. In addition, our oldest sample of children are considerably below ten years. However, it is not the purpose of this study to develop normative data with respect to dimensional preferences or multiple classification, but rather to describe how children select stimuli of different preferential value.

METHOD

Subjects. The subjects were 24 preschool (mean age 4-8) and 24 first grade (mean age 6-10) children. All children were drawn from a middle-class suburban school district and were evenly distributed with respect to sex. All the children were entirely cooperative and no subjects were lost.

Procedure The major features of the procedure used in this study included an opportunity for the children to group the stimulus dimensions which in this case were form, color and size. Since the study is not concerned with the children's ability to discriminate the values (red-blue-green; large-small and cube-sphere-pyramid) the differences in the stimulus values were highly discriminative. There were available 18 different stimuli. Thus, given children with normal sensory acuity (all the children were normal), it would be easy for them to discriminate the stimuli, in this case classify them, according to the predetermined categories. The question, then, is whether the children would spontaneously make the classifications. It should be noted that in addition to the single stimulus dimensions, the children could also double classify the stimuli (form-color, form-size, color-size) or form a triple classification (size-form-color).

As noted in the introduction to this report, there is already a considerable body of research evidence concerning developmental changes in saliencies of stimulus dimensions and in a real sense new data would be trivial. Our major concern, however, is with the selection sequences used by the children in selecting stimuli for their classifications. In an effort to obtain these data, the 18 geometric forms were arranged in a 5 x 5 matrix (seven stimuli were randomly selected from among the 18 to complete the 25 stimulus matrix) using the same arrangement for each presentation to each child and for all children. It is recognized that the selection sequences which will be reported are, because of the single matrix arrangement, confounded with arrangement; this procedure was necessary because of time and subject restrictions. In defense of the procedure, it is felt that our indices of sequences are not specific to stimulus arrangements but rather have a wider generalization value.

Each child was seen individually in the Department of Psychology's Mobile Laboratory, which was connected by cable to the cooperating school. The use of the Laboratory made space readily available and provided a constant environment devoid of extraneous noises and other distractions. The matrix of stimuli was placed before the child who was instructed to collect, "put together", all the stimuli that go together and then to state how the stimuli were the same. After completing the first trial, the stimuli were rearranged and the child was reminded of the basis of his first collection and told to put the stimuli together in another way. If it became apparent that the child was using the previously employed dimension, the stimuli were returned to their original positions and the child reminded that he had already used that dimension. If this procedure did not lead to another basis for categorizing the stimuli, the child was terminated and his score was recorded as "one" and the basis of his single selection noted. Typically the children could handle two of the dimensions (form and color); no child made a triple classification.

RESULTS

A preliminary analysis of the data was run to determine the degree to which our data corresponded to those reported in earlier studies related to dimensional preferences. It will be recalled that it was expected that the older children would show a greater preference for the form dimension while the younger children, it was assumed, would show a preference for the color dimension. It was further assumed that the older children would be more responsive to the size dimension than the younger children, although it was not clear how much more sensitive they might be. In considering our data, it should be recalled that our procedure forced the children to respond after their initial grouping. Thus, our results, in some respects, will be different, especially with respect to the younger children's ability to group on the basis of color.

Summarized in Tables 1 and 2 are the percentages of children selecting the various dimensions by age level.

Table 1

Percent Older Children's Dimensional Selections at Each Trial

Trial/Dimension	F	C	S	FC	FS	CS
1	79	21	0	0	0	0
2	18	75	7	0	0	0
3	4	4	68	0	0	0
4	0	0	0	17	4	0
5	0	0	0	0	8.2	0
6	0	0	0	0	0	4
N	24	24	18	4	3	1
%	100	100	75	17	12	4

Table 2

Percent Younger Children's Dimensional Selections at Each Trial

Trial/Dimension	F	C	S	FC	FS	CS
1	58	42	0	0	0	0
2	38	20	0	0	0	0
3	0	0	4	0	0	0
4	0	0	0	0	0	0
N	23	15	1	0	0	0
%	96	63	4			

Inspection of the data lends support to the conclusion that our procedure does not influence children's selective behaviors in any significant way although, as subsequent analyses will show, the effects are not quite as strong as those reported by others. Examination of Table 1 shows the expected hierarchy of dimensional preferences; form, color, size. There were relatively few children who generated double classifications and most of those involved their preferred dimension. All of the older children were able to classify on the basis of form and color and 75% classified on the basis of size. It is unclear whether the 75% is high or low since there are no other data of this type available. That the children did not use double classifications with any frequency is not surprising, at least in a Piagetian sense, since this competency probably occurs at a somewhat later age.

The data in Table 2 are for the younger children and show a somewhat different picture than for the older children. First, the older children were able to classify 53% over all trials whereas the younger children classified on only 27% of the trials. The major reason for this difference was the inability of the younger children to use size as a basis of classification and the fact that no young child employed a double classification. A second characteristic of the younger children's data is the less clear preference for form as a stimulus dimension and, of course, the higher percent of these children who could not, or would not, classify on the basis of color. In general the data lends support to the findings of others that there are developmental differences in stimulus preferences.

A series of statistical tests were conducted to determine the strength of the relationships described. In all instances these tests involved chi-square or Z tests for the differences between independent or dependent proportions. The first two tests conducted were run to determine if there exist significant age differences in choice of dimension. Trials one and two were examined separately and in neither case were the results statistically significant $\chi^2 = 2.4$, $df = 1$; and $\chi^2 = 2.1$; $df = 1$, respectively. In other words there were no age differences in the number of children who selected color or form on either trial one or two. A more direct comparison of the two groups with respect to choices on each trial was made using the Z test for independent groups. The Z for trial 1 use of form between the two age groups was 1.6; the Z for use of color on trial 1 was also 1.6; neither of these were statistically significant. A comparison of the two age groups with respect to the use of color on the second trial resulted in a Z of 4.6 which is significant at the .01 level. Performance of the age groups on the second trial with respect to form approaches statistical significance ($Z = 1.59$; $p = .055$).

In summary the analyses suggest that the procedure may have had some effect on the performance of the children but it was minimal. It is also possible that the characteristics of the children influenced the results in the sense that they are developmentally advanced over comparison groups available in the literature. It is clear from our data that fewer of the younger children were aware of the size discrimination, or at least categorized on that basis, and that few of the older children were able to make double classifications. These data are certainly consistent with theoretical considerations as well as other empirical findings.

The remaining aspects of the results section is concerned with the primary purpose of this study; namely the description of how children investigate the stimulus array and select their categories. A major problem with this aspect of the problem was concerned with how to score the response sequences used by the children in their choices in such a way that they made conceptual sense. The final solution may well be an over-simplification but it seemed that children who selected one stimulus attribute at a time in a sequence from left to right or right to left probably were demonstrating the most mature behavior. No differentiation was made between direction (left-right), so long as it was horizontal, on the grounds that mere efficiency might well dictate right-left-right-left, etc. So, the major concern was with the response sequence being horizontal. Next, we viewed a vertical selection of the same dimension as the next most sophisticated response. Note that we are assuming that a child who can retain the same stimulus property over all selections is displaying more sophisticated performance (coding?); this is purely an arbitrary assumption. In summary, our scale is based on the use of the horizontal plane and the use of a single stimulus attribute at one time. With these criteria in mind the following scale was employed:

1. 7 Points Successive adjacent identical stimuli (horizontal)
2. 6 Points Successive adjacent identical stimuli (vertical)
3. 5 Points Successive adjacent identical stimuli (random)
4. 4 Points Successive choice of stimuli (vertical)
5. 3 Points Successive choice of stimuli (horizontal)
6. 2 Points Successive choice of stimuli (random)
7. 1 Point Random selection of stimuli (vertical/horizontal)

The scale obviously permits the determination of a total score for each subject which would be a function of the number of categorizations made. This procedure would, however, confound the data with age. It was decided, therefore, to examine age differences on only the first two trials and then to examine the performance characteristics of the older children as the categorization behavior become more complex.

Table 3 summarizes the means and standard deviations for each age group in terms of the particular stimulus attribute (direct age comparisons involve only the form and color concepts; or the first two trials.

Table 3

Mean and SDs Scanning Scores for Form and Color for

Young and Old Children

	Old		Young	
	M	SD	M	SD
F	6.1	1.3	2.7	1.9
C	5.4	1.4	1.5	.3

An ANOVA involving one variable between groups (age) and one variable within groups (stimuli selected; form vs color) was conducted on the derived index of selection proficiency. The results indicated a significant age effect ($F = 3.9$; df 1/94; $p = .001$); neither the stimulus nor the stimulus by age interaction was significant. With respect to the selection of the size dimension, for the older subjects only, the predominant strategy was to select alternate sizes (large, small) or group as the stimuli occurred. In every one of the 18 cases the direction of selection was horizontal.

DISCUSSION

There were relatively few surprises in the data especially with respect to the age differences in the number of stimulus dimensions selected and the pattern of selections. Perhaps the one minor exception to this conclusion was the finding that the distinction in the use of color and form among the younger children was not as sharp as one might have imagined in light of other data (Brian and Goodenough, 1929). Although this minor difference may have been a function of the procedures used in this as opposed to the earlier study, there may well be a more theoretically interesting explanation. The case assumes that our children were cognitively more mature. Thus, it is proposed that as children mature cognitively (develop and elaborate structures), they become aware of the stimulus dimensions available in their environment. Obviously, children can discriminate colors long before they voluntarily employ color as a basis for categorization. Similarly, young children are aware of size differences but even as late as seven years they do not systematically use the dimension in most experimental contexts. The hypothetical argument being made here is that in most situations neither color or size are particularly important stimulus attributes and are therefore ignored. This position is more than a reinforcement position because it suggests a reason why younger children, and some ("slower") older children do not know the names of the primary colors; they are unaware of color as a stimulus dimension when embedded in other dimensions. If this argument is correct, it would suggest that the mere act of teaching children the names of colors achieves little more than teaching them the names of colors.

The important data found in this study relate to the differences in strategies used by the children with easier as opposed to the more difficult dimensions. Specifically, we found that older children, when grouping on the basis of color or form select a specific stimulus property and exhaust that property in a systematic horizontal direction proceeding until they exhaust all members of the dimension. Younger children, with respect to form and color, can, in fact, adequately group the stimuli but do so in a much more random almost haphazard fashion. It would appear that the younger children are more bound by the immediate stimulus event but, as it turned out, that event could occur almost anywhere in the matrix. Some of the patterns of choices were amazingly similar to the descriptions of eye tracks reported by Mackworth and Bruner (1970) and Zinchenko (1963); sudden long leaps across the space of the matrix which, in the case of these two studies, gained the subjects essentially little or no useful information. It is, of course, unclear why this phenomena occurs and it does not seem adequate to suggest that systematic scanning (or stimulus selecting) is a function of having been taught to read (although surely reading had some direct effect on the left-to-right choices of the older children in this study). There is undoubtedly something more complex involved in the changes that have been observed in eye movement patterns during the four to eight year period which may be related to the changes described by White (1965) in a broad variety of cognitive behaviors. Further research is clearly needed to identify the precise nature of these mechanisms.

A parallel set of behaviors was observed among the older children when they were working with the size dimension and with those few older children who were able to generate multiple classifications. Specifically, though the older children maintained a systematic sequence of choices, they selected each stimulus as it occurred rather than collecting all identical stimuli at one time. In other words, it appeared that as the stimulus dimension(s) became more complex, or at least, less familiar to the child, the grouping behavior became somewhat less "mature". This finding is consistent with the general observation that as problems become more difficult, human beings often revert to behaviors which have been previously successful.

A final observation seems worthwhile from these data. It would seem that in organizing stimuli for young children, salient features (as defined by the adult) should be clearly isolated and not cluttered with other irrelevant stimulus features often included for aesthetic purposes. Indeed, it might be worthwhile if more authors and other developers of learning materials would pretest their work to determine that in fact the child is even aware of what the adult views as the salient feature. It would also appear that children who are unable to voluntarily systematically search stimulus arrays should probably not be expected to readily learn to read; and this goes beyond the issue of whether the child can employ multiple classifications. Thus, in addition to being able to decentrate, as Elkind has shown, it also appears that the child needs to know how to search for salient features. In the judgment of this investigator, when the child decentrates he probably also begins a more systematic search pattern and this presumed relationship, it is suggested, is a function of cognitive development and not a perceptual function.

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